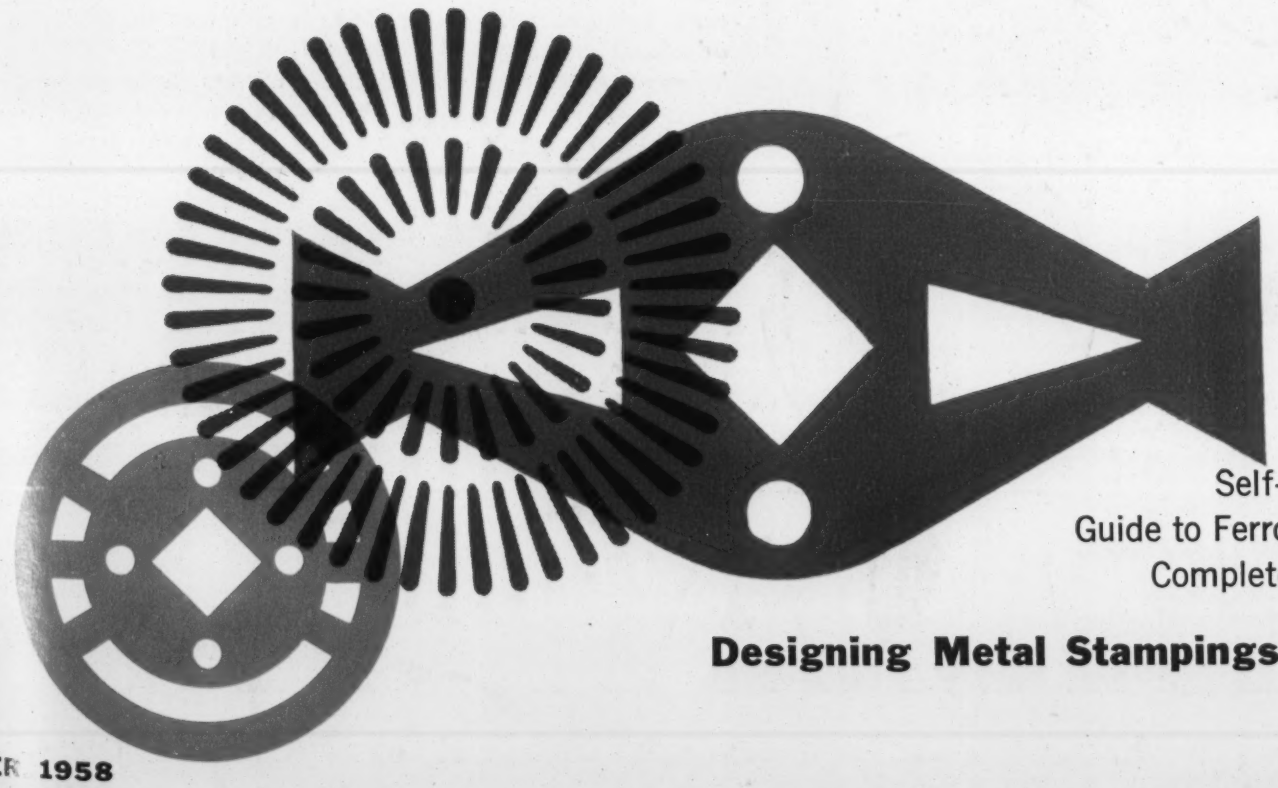
Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

MICHIGAN
SEP 1 1958
ENGINEERING
LIBRARY

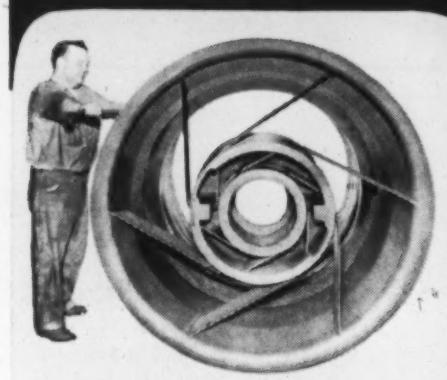
SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

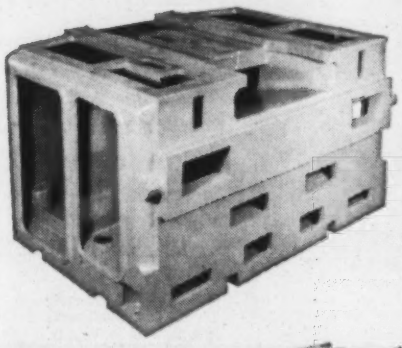


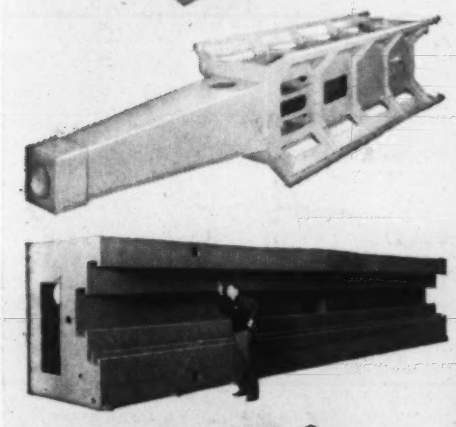
Also:
Self-Luminous Materials
Guide to Ferromagnetic Ceramics
Complete Contents—page 1

Designing Metal Stampings Manual No. 152

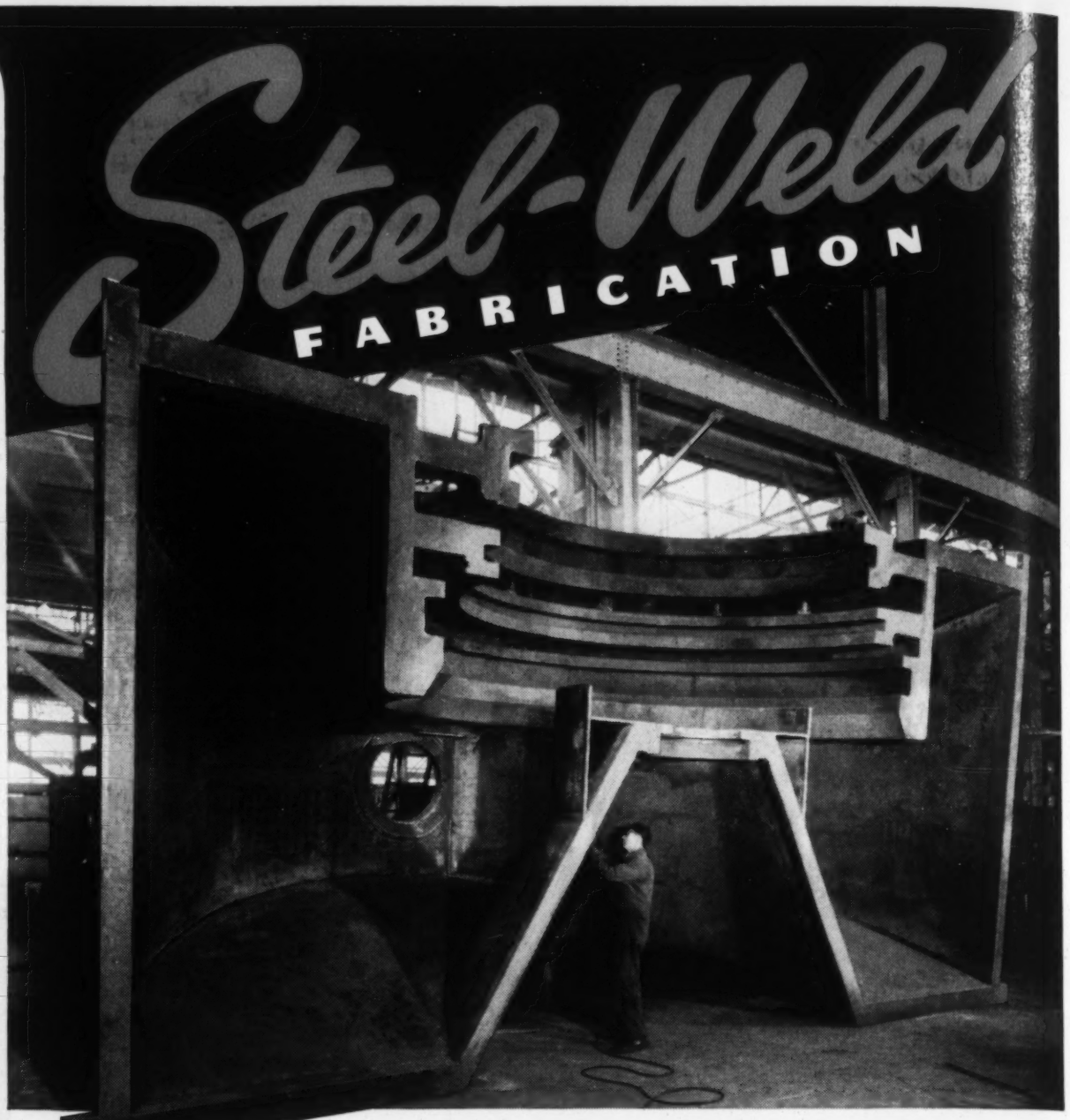
MBER 1958

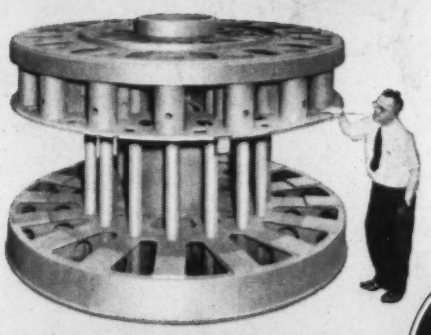




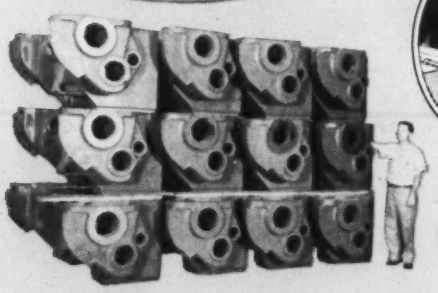


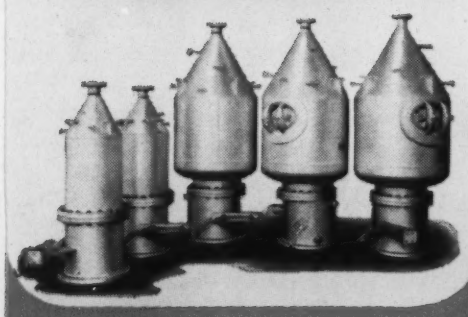
Steel-Weld FABRICATION





Use WELDED STEEL for Greater Strength with Less Weight!





The weldment illustrated above is the Cover Section of the housing for a 300,000 kw Steam Turbine . . . it weighs 55 tons. This unit and those shown at the left are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are you taking full advantage of the economies offered by welded steel components in your products? In the design of almost any type of heavy machinery, or mechanical engineering project, there are parts and sub-assemblies that can be produced more economically and more satisfactorily in welded steel . . . because, in weldments you save time and pattern costs, and you get greater strength with less weight, plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed-up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

For more information, turn to Reader Service card, circle No. 418

WILLIAM P. WINSOR
Publisher

H. R. CLAUSER
Editor

HAL B. CAMPBELL
Managing Editor
JOHN L. EVERHART
Technical Editor
ROBERT J. FABIAN
Associate Editor
JACK C. MERRIAM
Associate Editor
MALCOLM W. RILEY
Associate Editor
WALTER LUBARS
Assistant Editor
JOHN A. MOCK
Assistant Editor
HARRY KOKIS
Editorial Production Assistant
GIL MILLER
Art Director

M. RANDOLPH LONG
Advertising Sales Manager
JOHN Y. CUNNINGHAM
Research & Promotion Manager
JOHN N. CARLIN
Circulation Director
JOHN A. KOVCHOK
Production Manager
WILLIAM SCOLLON
Advertising Production Assistant
E. M. WOLFE
Manager, Reader Service

PUBLISHED BY
REINHOLD PUBLISHING CORP.
430 PARK AVE., NEW YORK 22, N. Y.

RALPH REINHOLD, CHAIRMAN OF THE BOARD
PHILIP H. HUBBARD, PRESIDENT & TREASURER
K. A. STARKE, ASSISTANT TREASURER
F. P. PETERS, VICE PRESIDENT & SECRETARY
A. E. FOUNTAIN, VICE PRESIDENT
H. BURTON LOWE, VICE PRESIDENT
MERALD LUE, VICE PRESIDENT
O. BRAD WILKIN, VICE PRESIDENT
WILLIAM P. WINSOR, VICE PRESIDENT

PRICE $1.00 PER COPY, EXCEPT MID-OCTOBER ISSUE NOT SOLD SEPARATELY. PAYABLE IN ADVANCE, ONE YEAR, $3.00; TWO YEARS, $5.00 IN U.S. POSSESSIONS AND CANADA. IN ALL LATIN AMERICAN COUNTRIES: ONE YEAR, $10.00; TWO YEARS, $16.00. ALL OTHER COUNTRIES: ONE YEAR, $15.00; TWO YEARS, $25.00 (REMIT BY NEW YORK DRAFT). PUBLISHED MONTHLY, WITH AN ADDITIONAL ISSUE IN MID-OCTOBER. COPYRIGHT, 1958, BY REINHOLD PUBLISHING CORP., NEW YORK, N. Y. PRINTED BY PUBLISHERS PRINTING-ROGERS KELLOGG CORP. INDEXED REGULARLY IN ENGINEERING INDEX AND INDUSTRIAL ARTS INDEX.
POSTMASTER: SECOND CLASS MAIL PRIVILEGE AUTHORIZED AT NEW YORK, N.Y. SEND FORM 3579 TO MATERIALS IN DESIGN ENGINEERING, 430 PARK AVE., NEW YORK 22, N.Y.
SUBSCRIBERS: SEND SUBSCRIPTION CORRESPONDENCE AND CHANGE OF ADDRESS TO MATERIALS IN DESIGN ENGINEERING, 430 PARK AVE., NEW YORK 22, N.Y., GIVING OLD AS WELL AS NEW ADDRESS, AND INCLUDING CITY POSTAL DELIVERY ZONE. IF POSSIBLE ENCLOSE LATEST ADDRESS LABEL. ALLOW TWO MONTHS FOR CHANGE.

Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

SEPTEMBER 1958
VOL. 48, NO. 3

FEATURES

Self-Luminous Materials ..... *J. L. Seminara* **89**
Coatings that glow in the dark without excitation show promise for signs, locators, instruments

Why and Where to Use Centrifugal Castings—Part 2 ..... *J. L. Everhart* **93**
Nonferrous uses include bearings, papermaking rolls, pressure vessels, gears, machine parts

A Guide to Ferromagnetic Ceramics—Part 1 ..... *G. Economos* **96**
How ferrites work, and an exclusive tabulation of properties for all commercial soft ferrites

Selecting Materials to Avoid Cavitation Damage ..... *W. J. Rheingans* **102**
Aluminum bronze and stainless steel seem to stand up well when used in hydraulic equipment

Laminated Plastic Gears: Silent Operation, High Horsepower ..... *G. J. Muller* **106**
Properties of the important gear laminates plus the formulas needed for effective design

MANUAL NO. 152
Designing Metal Stampings ..... *J. L. Everhart* **109**
A 16-page article: how to design for stamping, and working properties of the metals used

DEPARTMENTS

MATERIALS AT WORK **9**
Urethane Foam for Unsinkable Boat—*9*. Circuit Breaker Contacts Visible—*10*. Valve Stem of Zirconium—*10*. Hinged Die Castings—*11*. Other Contents—*12*.

TECHNICAL LITERATURE **39**
Suppliers' New Bulletins—*39*. Books—*206*. Reports—*208*.

FILE FACTS
Cast High-Leaded Tin Bronzes—a Materials Data Sheet **127**

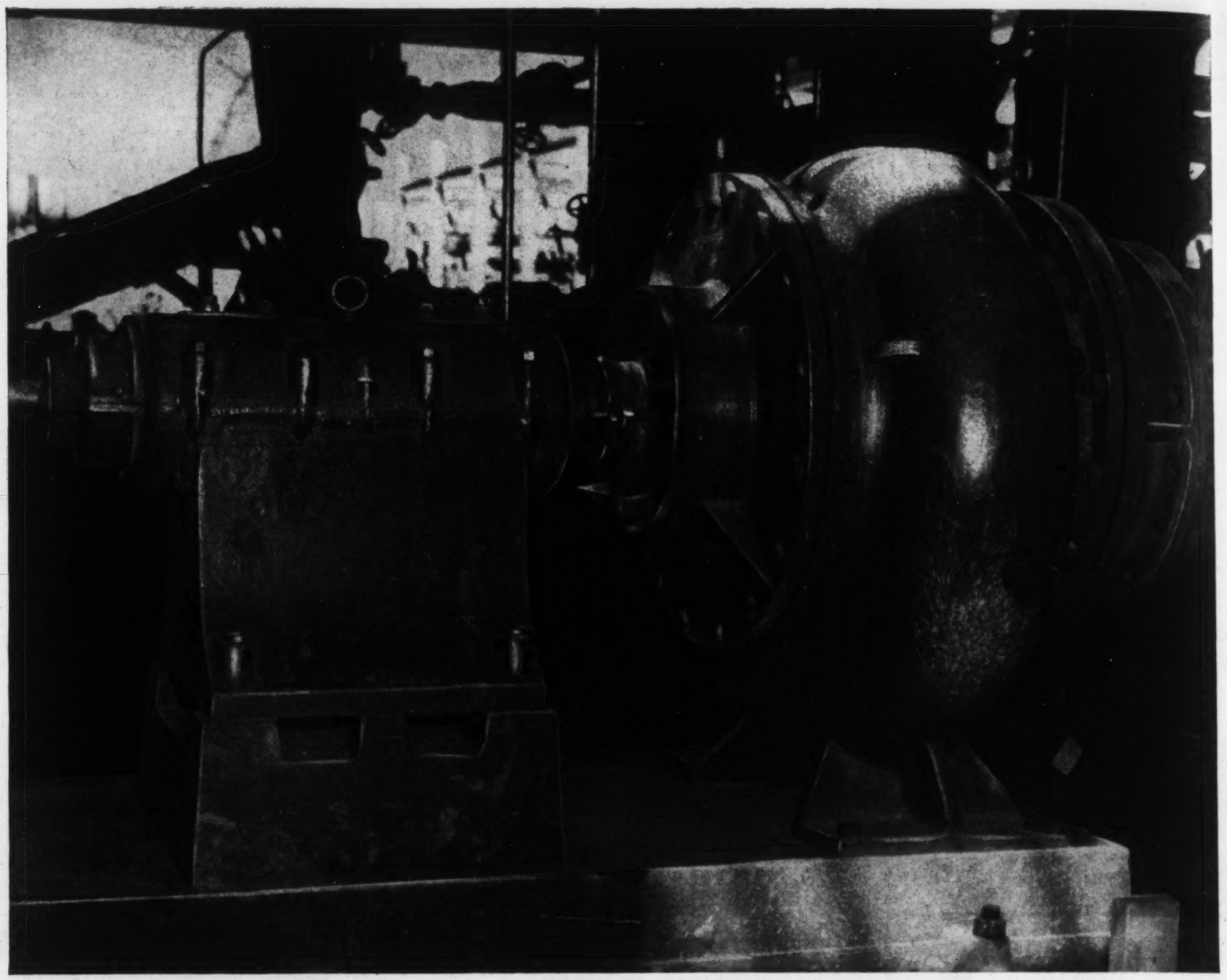
WHAT'S NEW IN MATERIALS **129**
At a Glance—*3*. Thermal Insulation Is Acid Resistant—*129*. Polypropylene Yarn for Rope, Fabrics—*130*. First All-Beta Titanium Alloy Has 240,000 Psi Strength—*131*. Aluminum Alloy Withstands 500 F—*140*. Other Contents—*132*.

PRICES AND SUPPLY **181**
At a Glance—*181*. Quarterly Report on Prices of Materials—*183*.

NEWS OF INDUSTRY **191**
First Design Materials Show—*191*. Rubber Hardness Test Standardized—*191*. News of Engineers—*194*. Companies—*198*. Societies—*202*. Meetings—*204*.

OTHER DEPARTMENTS
Briefs—*7*. Letters—*14*. Reader Service—*37*. Advertisers—*212*. The Last Word—*214*.

COVER BY HARRY & MARION ZELENKO



ONE OF TRIPLETS. Three pumps with Inco-cast Nickel housings push cell liquor through heat exchangers within triple-effect evaporators at a new caustic-chlorine plant. Inco-cast Nickel provides high resistance to caustic embrittlement...brine corrosion...abrasion from solids.

How would you handle 46% caustic, 12% salt slurry?

This pump circulates cell liquor and caustic soda through heat exchangers in triple-effect evaporators.

Caustic concentrations run as high as 46% . . . salt slurry concentrations up to 12%.

Nickel was specified for the housings because it resists attack from brine corrosion, caustic embrittlement, and abrasion from solids.

But these excellent properties are of little value unless they are incorporated in high quality castings. That's why Kingsford, the pump fabricator, comes to Inco's own foundry for Nickel housings.

To get the most out of Nickel and high nickel alloy castings, have them Inco-Cast. This is the best way to make sure your castings will have all of the properties that make Nickel superior to any other commercially available metal for handling caustics.

So, when you're up against destructive service conditions, be sure to investigate the advantages of Inco-cast Nickel and other Inco-cast Alloys. You'll find some good, usable information in our Data Folder, *Engineering Properties of Cast Nickel.* Write for a copy.

THE INTERNATIONAL NICKEL COMPANY, INC.
Bayonne Works
15 Oak Street — Bayonne, N. J.

INCO-CAST PRODUCTS

For more information, turn to Reader Service card, circle No. 488

What's new IN MATERIALS

...AT A GLANCE

A NEW FLUID RESISTANT SILICONE RUBBER has been developed. The material, nitrile silicone rubber, is said to combine the good heat resistance of silicone (-100 F to 500 F) with the excellent solvent resistance of nitrile rubber. Potential uses include o-rings, seals, gaskets and hoses for use in aircraft, automobiles, electrical devices and railroad equipment. Introductroy price is $15 per lb. (More details next month.)

CALCIUM METAL STRIP IN THICKNESSES DOWN TO 0.005 IN. is now commercially available; the metal is also available in a variety of standard mill shapes. Calcium metal has a specific gravity of 1.55, a modulus of elasticity of 3 to 4 x 10^6 psi, and an electrical conductivity about 45% that of pure copper.

A NEW TEST FOR CHECKING THE BOND IN HONEYCOMB STRUCTURES has been developed. The nondestructive test involves applying heat to the surface of a structure that has been sprayed with a fluid that repels heat. Since the fluid repels heat and tends to flow to a cool area, it accumulates at every point of good bond and reproduces this pattern on the surface of the structure.

FILAMENT-WOUND CERAMIC SHAPES, consisting of filament-wound glass fibers bonded with a ceramic colloid, seem quite promising for large, strong, lightweight and relatively non-brittle shapes, e.g., missile components and radomes. Still in the development stage, filament winding lends itself to fabricating large shapes that are difficult to form by conventional ceramic fabricating techniques. The filament-wound shapes require only sintering at relatively low temperatures.

A HIGH SPEED METHOD FOR BONDING CEMENTED CARBIDE TO STEEL has been introduced recently. According to the developer, resulting bond strength is greater than the strength of either the steel or the carbide. The process is promising for small cutting tools and other parts subject to wear and abrasion.

A MOLYBDENUM TURBINE PART PERFORMS WELL AT 2000 F when coated with four layers of protective materials, according to

recent research. The protective layers are: 1) a chromium electroplate to give a diffusion-type bond; 2) a nickel electroplate to improve ductility; 3) a fused nickel-silicon-boron coating to improve oxidation resistance; and 4) a 0.006-in. spot welded layer of Nichrome as a final cladding.

A NEW RIGID THERMOPLASTIC PIPE, said to have higher working pressure ratings than other rigid thermoplastic pipes of the same size, is now commercially available. Made of an improved thermoplastic resin, the pipe withstands temperatures as high as 180 F. The pipe can be cut with a saw and can be jointed by solvent welding.

MORE HEAT RESISTANT JET ENGINE PARTS can be obtained by using a new nickel-base titanium-aluminum sheet alloy that is said to be resistant to temperatures up to 1800 F. A heat treated sample of the new alloy had a yield strength of 125,000 psi at 1200 F and a 100-hr stress-rupture strength of 25,000 psi at 1600 F. The developer says the alloy is suitable for afterburner parts, turbine casings, nozzle diaphragm partitions and combustion liners.

GLASS-COATED CERAMIC CAPACITORS are now available for continuous operation at temperatures from -76 to 437 F. The developer says the units, which are subminiature in design, have successfully passed 1000-hr life tests at 437 F at twice their rated voltage: The capacitors have pure silver leads to provide for ease of soldering.

ALUMINUM CAN BE JOINED TO STAINLESS STEEL by a new bonding process which actually consists of die forging. According to the developer, the bonding process can also be used to join aluminum to copper, alloy steels and other aluminum alloys. Products that can be made with the new bonding process include aluminum-stainless steel pans and electric skillets.

LIQUID METALS MAY SOMEDAY BE USED AS HYDRAULIC FLUIDS in aircraft systems operating at 1000 F, recent research indicates. Tests show an alloy of sodium and potassium has low density, high bulk modulus, low vapor pressure and good thermal stability. Two drawbacks: the liquid metals have negligible lubricity and a high affinity for oxygen.

Turn to page 132 for more "What's New in Materials"

MATERIALS BRIEFS

Aluminum Helps Runways, Too

A reflective aluminum sheet laminated on one side with metallized polyester film is used in a new airport runway lighting system. The sheet, placed behind 8-ft long fluorescent tubes, projects a 1400-ft continuous strip of light on both sides of a runway in a horizontal pattern.

An Electrifying Development

A rubber belt and a plastics pulley are the principal parts of an educational device used to demonstrate static electricity. When the belt is run over the pulley the machine builds up a static charge of 250,000 v which can be passed safely through a human body because of the low current (8 to 15 μa).

Titanium for Billboards?

Billboard trim made of titanium is standing up to the ravages of rain, wind, snow, insects and poster paste better than trim made of wood or aluminum. Poster paste, a mixture of paste and calcium chloride, is extremely corrosive to most materials.

Throw-Away Suit

The Army has developed a fire fighting suit made of aluminum-coated kraft paper which is expendable. The suit is designed so that it may be thrown away after it has served its purpose.

Better Baby Buggy

One-piece fiberglass-reinforced plastic baby buggies named after the world's leading ballerinas are available. They are said to be squeak-free, rustproof and easy to handle.

HOW CAN BRASS POWDER METALLURGY HELP YOU?

BY MAKING PRECISION PARTS ... AT QUANTITY COSTS

The biggest single factor favoring the use of powder metallurgy is *economy*. Within design limitations, the process is one of the lowest cost mass production methods —even for relatively small quantities of high quality precision parts.

Brass powder metallurgy has many advantages which contribute to economy of the process:

- ... ***low scrap loss***
- ... ***high dimensional accuracy***
- ... ***controlled mechanical properties***
- ... ***uniformly high quality***
- ... ***savings in assembly time***

A powder metal fabricator can show you how brass powder metallurgy will produce precision components at low cost for your products—along with many other advantages.

THIS BOOKLET

will assist you in evaluating this modern production method in terms of your particular needs.

SEND FOR YOUR COPY

THE NEW JERSEY ZINC COMPANY
160 Front Street, New York 38, N. Y.

HORSE HEAD PRODUCTS

For more information, turn to Reader Service card, circle No. 474

B.F.Goodrich

B. F. Goodrich makes *more* than solid rubber — more than tires, belts and hose. We make *cellular* materials, rubber and plastic, that range from powder-puff softness to rock hardness. These materials insulate, absorb shock, seal, cushion, float and damp vibrations. And under practically any conditions — such as heat, cold, moisture, dryness, acidity, dust or oil.

Standard sheet stock, cord, and tubing are immediately available. Die-cut shapes and molded strips and forms are made to your specification. Large runs naturally get a better price. For complete information on any or all B. F. Goodrich cellular materials write The B. F. Goodrich Company, 421 Derby Place, Shelton, Connecticut. Or if your problem needs immediate discussion phone Cellular Engineering, REgent 5-4661.

B.F.Goodrich

industrial cellular materials

For more information, turn to Reader Service card, circle No. 420

MATERIALS AT WORK

New and interesting applications of engineering materials

Urethane is foamed in place . . .

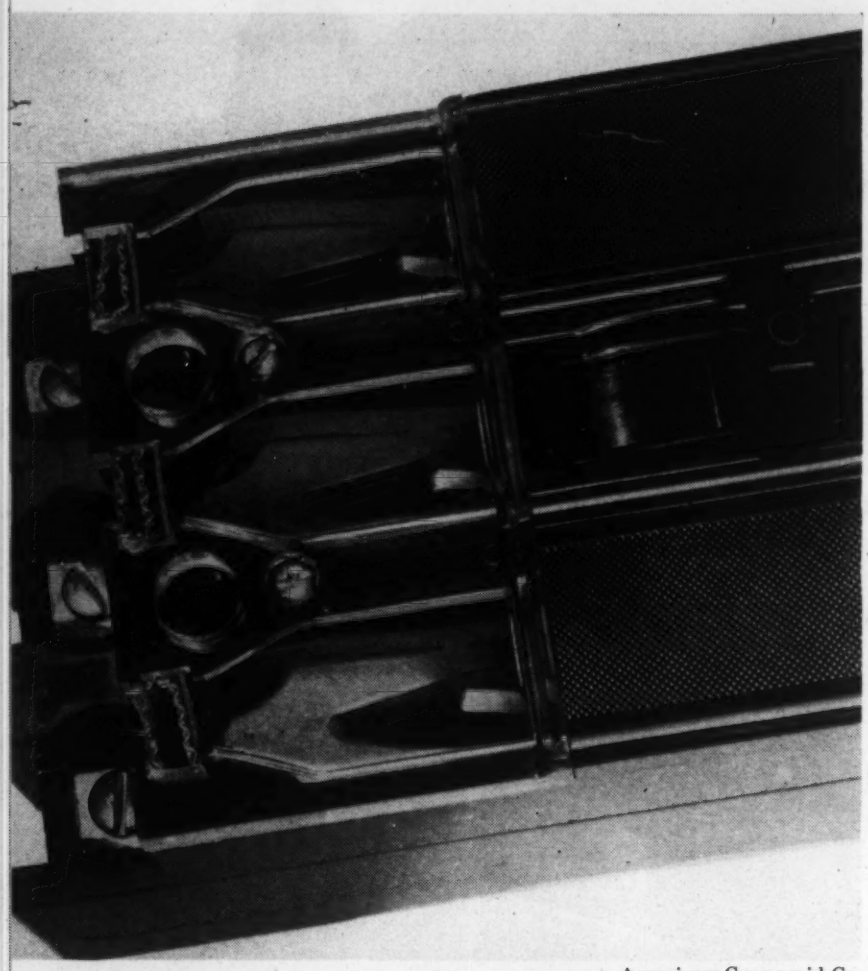
. . . excess foam is trimmed, and . . .

. . . boat is virtually unsinkable.

Foamed-in-place urethane makes boat unsinkable

The substitution of a plastics laminate for thin cedar wood and urethane foam for expanded polystyrene has resulted in substantial reductions in cost and production time in the manufacture of lightweight, unsinkable boats.

According to Allied Chemical Corp., the use of glass-reinforced polyester resin for the boat body has reduced cost by about 50% and manufacturing time from 250 to 25 hr. The advantages listed for foamed-in-place urethane over cut blocks of polystyrene include: 1) reduced cost and time of installation; 2) uniform fit, providing added strength and rigidity; and 3) exceptionally strong adhesion to the polyester resin, thus sealing any pinholes which might appear in the laminate.



American Cyanamid Co.

MATERIALS AT WORK

First circuit breaker with visible contacts

A removable, transparent cover made of methylstyrene-acrylonitrile has enabled Westinghouse Electric Corp. to produce what is believed to be the first electrical circuit breaker in which the contacts are clearly visible (see photo at left). The obvious advantage of this innovation is that trouble can be spotted instantly: the cover immediately darkens in the event of a short circuit.

Methylstyrene-acrylonitrile was selected for this application because " . . . it provides the necessary transparency, surface hardness, and heat and break resistance at comparatively low cost."

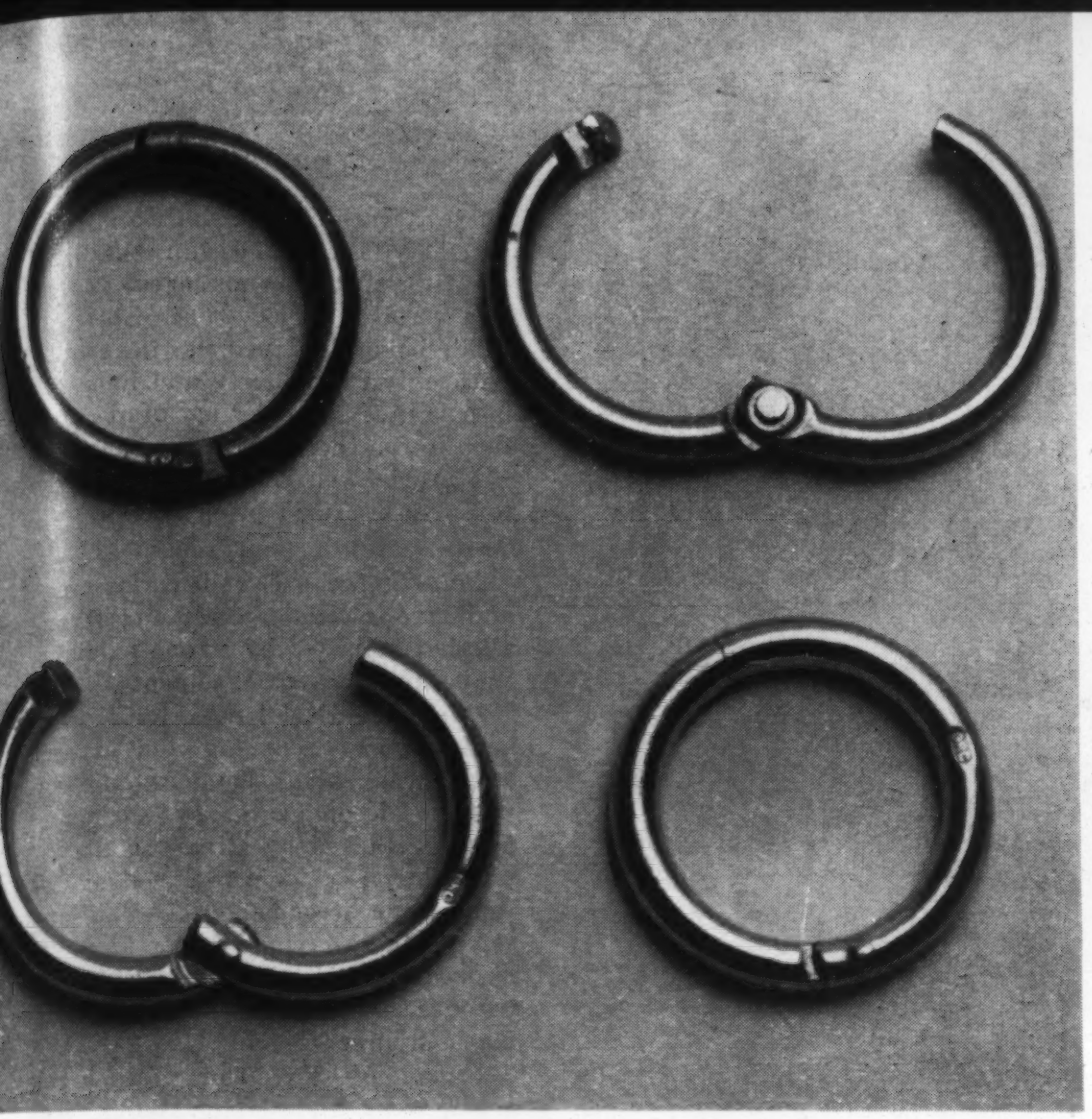
Zirconium valve stems outlast stainless steel

The switch from type 316 stainless steel to zirconium has resulted in a considerable extension of service life for valve stems subject to highly corrosive liquid chlorine. According to Columbia-Southern Chemical Corp., zirconium stems last as much as 20 times longer than previously used steel stems.

The valve failures that occurred when stainless stems were used resulted from the etching and/or grooving of the valve stem and packing gland follower in the packing zone. At this point moisture in the air combines with the chlorine gas and chemical attack progresses rapidly, making it extremely difficult or impossible to maintain a gastight seal.

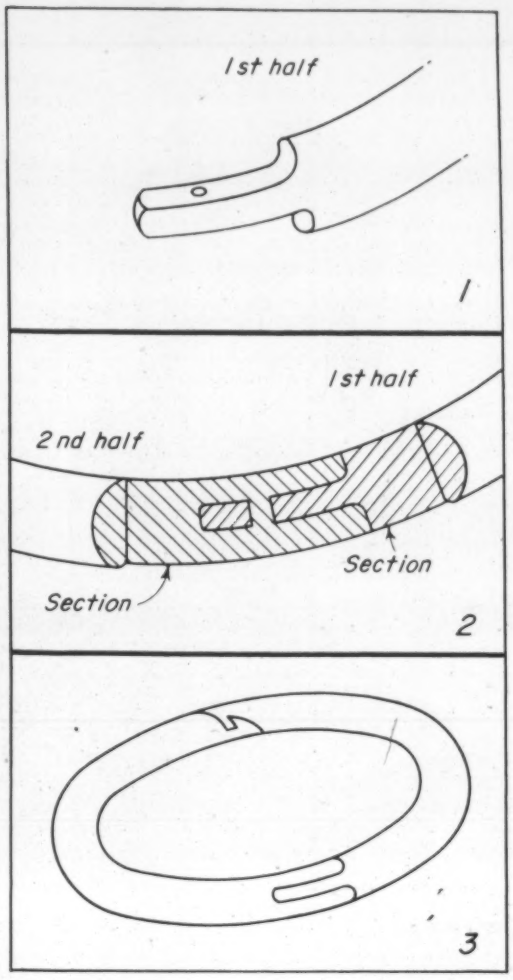
According to Columbia, other materials, such as titanium, high nickel alloys and superalloys, were tested for this application, but all failed.

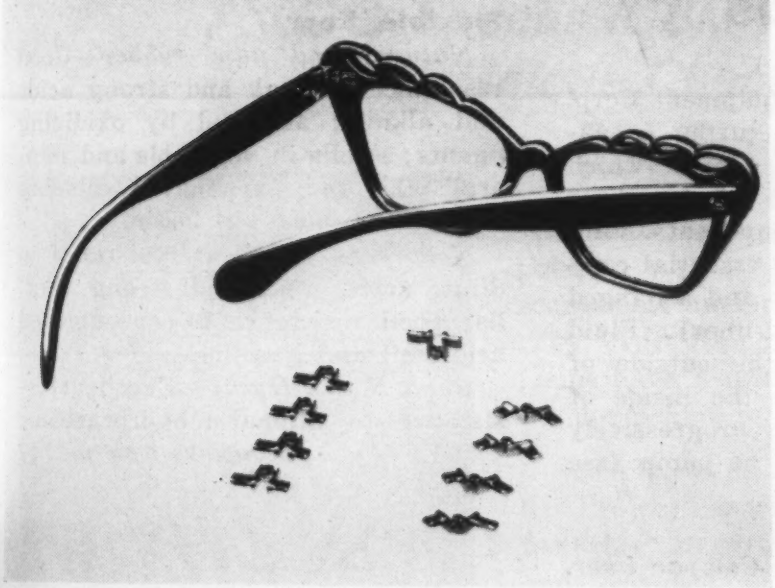
Valve with zirconium stem *(below left) has been in service for two years without failure; valve with stainless (below right) failed after only six months.*



Movable binder ring *is cast in one operation.*

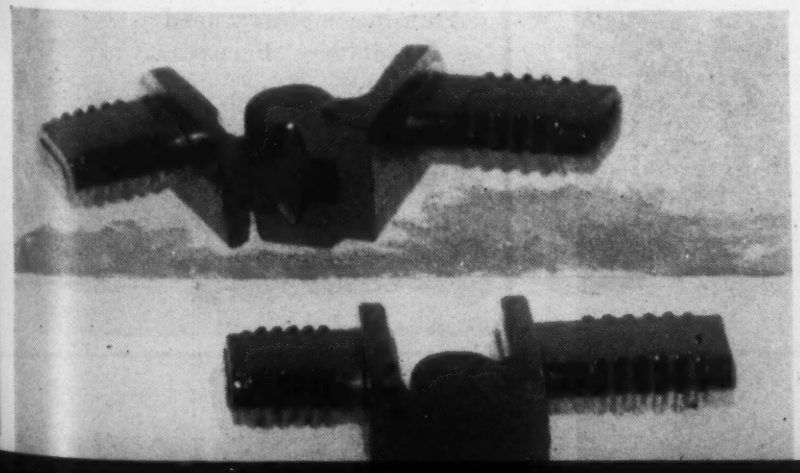
How it's done . . .





Movable hinge *for eyeglass frame, like binder ring, is cast in one operation.*

Close-up *of eyeglass hinge. Joints have been ground down to show perfect fit of mating parts: when the hinge is closed, separation lines are barely visible.*



Hinged die castings

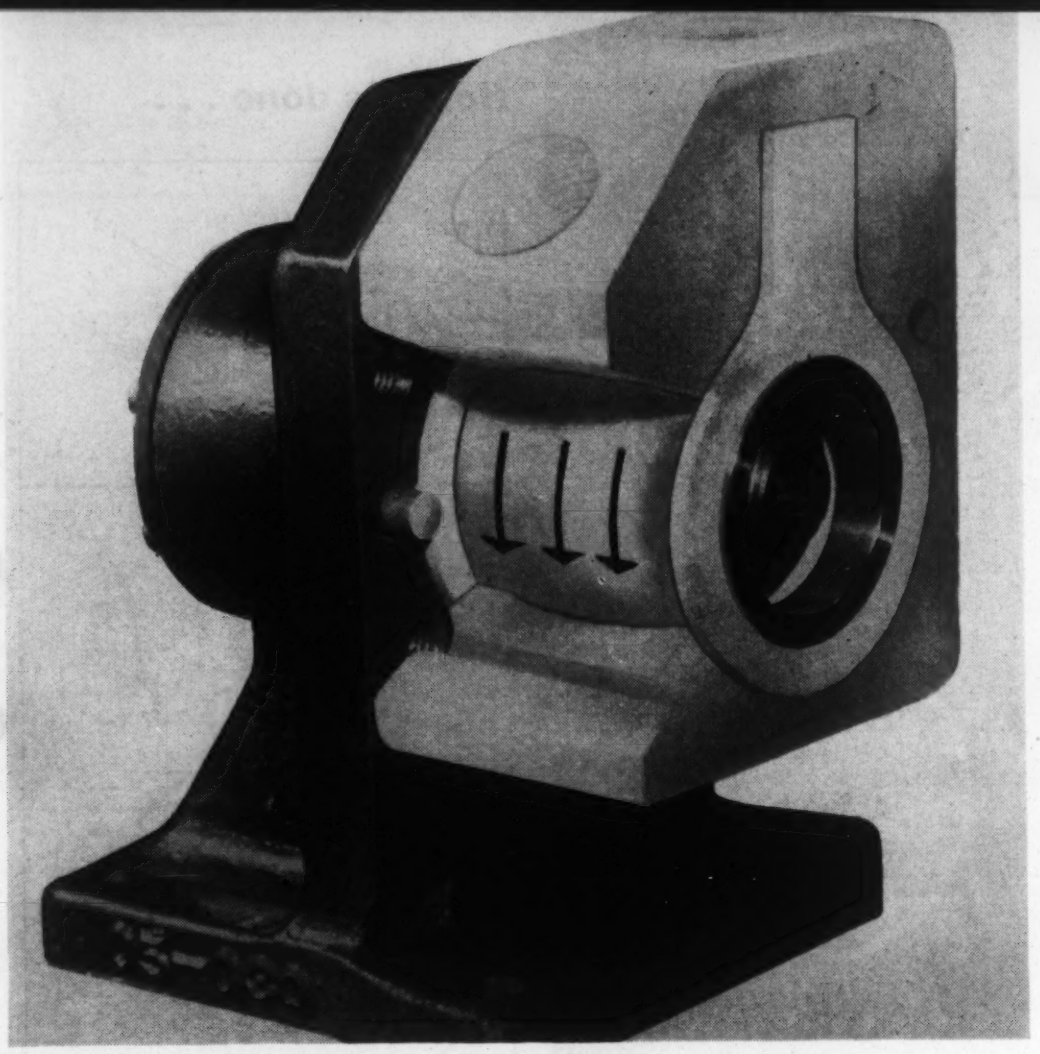
The binder ring shown in the photo above is a zinc die casting produced by the Intercast process—a technique that turns out in one operation a part with movable sections all assembled and ready to work.

Here's how it works, according to Gries Reproducer Corp., developers of the process: As the first half of the ring is die cast (see sketches), the zinc alloy solidifies rapidly and the ring's ends become part of the die for the second half (1). The metal for the second half enters a split second later, flowing around the tongue and through the pivot hole of the solidified first half (2), forming an integral assembly (3).

Another part now being made by the Intercast process is the eyeglass hinge shown in the photos at the left. Previously, the hinge consisted of three separate parts—two hinge halves and a hinge pin—and required multiple assembly operations: each hinge was cut from an extrusion, slots were milled for the hinge leaves, riveting holes were punched, and a hinge pin hole had to be machined. Now, one operation produces the complete hinge ready to work. The studs with annular teeth are integrally cast to the movable hinge leaves, and the entire unit is molded right into the plastics eyeglass frames.

In addition to obvious design advantages, the following cost benefits are claimed for the process: 1) elimination of all assembly costs; 2) reduced labor costs; 3) reduced cost of materials; and 4) high production rate at relatively low tooling cost. In addition, single-cavity dies are used, thus assuring uniformity from part to part.

The one major limitation inherent in the process is the size of parts that can be produced: 5 oz max weight and 1½ in. max length.



Cut-away of Vanton's pump *showing body block and flexible liner. (Arrows indicate direction of fluid, which contacts only these two parts of pump.)*

Plastics and rubber materials now used in industrial pumps

The use of plastics and rubber materials in the design of industrial equipment has grown considerably over the past two or three years. However, the acceptance of these materials for moving or major parts of chemical equipment such as pumps has been relatively slow. One reason has been the lack of sufficient knowledge of what each of the presently available materials can and cannot do.

Vanton Pump & Equipment Corp. is presently manufacturing a variety of industrial pumps which utilize many plastics and rubber materials in vital components. Vanton's pumps have two essential components: a body block and a flanged flexible liner (Flex-i-liner). Fluid is trapped between the outside of the flexible liner and the inside of the body block and is progressively "squeegeed" through the pump (see photo). An eccentric shaft and rotor assembly rotates within the liner creating an action analogous to rolling a roller over a hose. Since the fluid being pumped is in contact with only the housing and liner, the importance of choosing proper materials for these parts is evident.

Materials currently used by Vanton are described briefly below.

Body block

Polyethylene—Excellent for weak and strong acids, weak and strong alkalis; attacked by strong oxidizing acids and aromatic solvents.

Phenolic—Excellent for weak acids, strong reducing and organic acids, weak alkalis and organic solvents; decomposed by oxidizing acids; attacked by strong alkalis.

Polyvinyl chloride—Excellent for weak and strong acids, weak and strong alkalis, alcohols, aliphatic hydrocarbons and oils; soluble in ketones and esters; swells in aromatic hydrocarbons.

Buna N—Excellent for weak acids, weak and strong alkalis, vegetable and mineral oils, and aliphatic and aromatic hydrocarbons.

Teflon—Excellent for weak and strong acids, weak and strong alkalis and organic solvents.

Flexible liner

Natural and gum rubber—Good resistance to weak and strong acids and alkalis; attacked by oxidizing agents; swells in vegetable and mineral oils, and oxygenated solvents such as alcohols and ketones.

Neoprene—Excellent resistance to dilute acids, weak and strong alkalis; good resistance to concentrated acids, oil and gasoline.

Buna N and Hycar—Excellent resistance to aliphatic hydrocarbons,

(continued on p 174)

Carbon tetrachloride pump *uses phenolic body block and Compar liner.*

MORE MATERIALS AT WORK

Aluminum plates used for drivers' licenses.....174

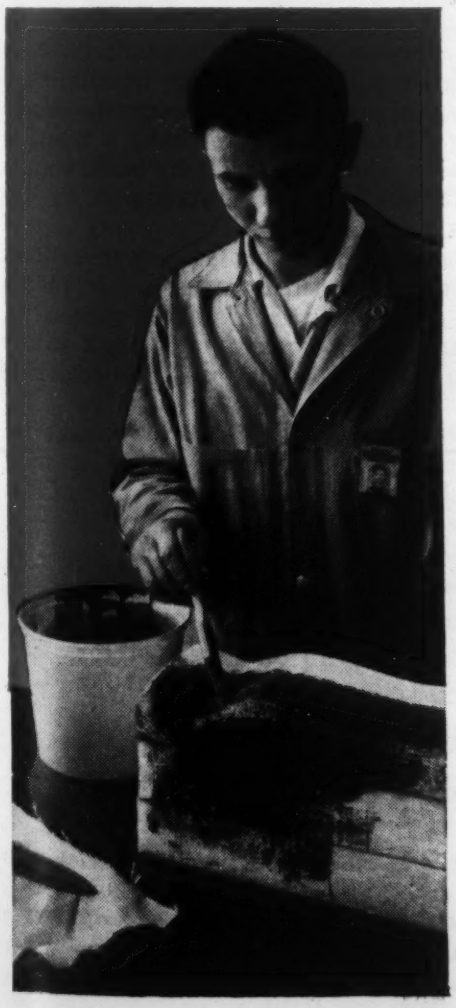
A world of nylon.....174

Vinyl foam cushion has molded-in cores 176

Stainless pressure vessel.....176

AVCO *Speeds ICBM Nose Cone Development With Unique Checking Tools Made of*

RCI Epoxy Resins and Polyurethane Foam



"In producing experimental missile components, we need a fast, foolproof and economical method of checking accuracy. And Reichhold EPOTUF epoxy resins have played a major role in our development of just such checking units."

Speaking is Mr. Bob Thompson, Plastics Project Leader, Experimental Manufacturing Department, AVCO Research and Advanced Development Division, Lawrence, Massachusetts.

AVCO's experimental work on the Titan ICBM nose cone is a vital, high priority project. Complex parts must meet exact tolerances. The slightest imperfection might cause failure.

For instance, one length of pipe for the nose cone twists and turns sixteen different times in its 34-inch length. To test the accuracy of each bend, AVCO has developed tools such as you see above made of RCI epoxy resins and RCI polyurethane foam. Such devices can be made quickly and inexpensively, and solve one of AVCO's toughest testing jobs.

"Furthermore, another benefit we gain in dealing with RCI is invaluable technical aid," Mr. Thompson stated. "Also we have never experienced any delays in delivery ... and we absolutely need this kind of service."

Perhaps dependable, versatile RCI EPOTUF epoxy resins or RCI POLYTOOL plastic tooling compounds will improve *your* application. Write RCI for details.

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate
Sulfuric Acid • Methanol

Creative Chemistry ...
Your Partner in Progress
RCI

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

For more information, turn to Reader Service card, circle No. 441

The NEW Minicast Process

. . . produces miniature precision metal parts at less cost than those produced by other precision methods . . . at no sacrifice in quality

Only Pennies Per Part

■ The Minicast process is the unique, new precision forming process that successfully combines the basic advantages of the investment casting process with those of such other precision methods as coining, cold forming, screw machine production, and the like.

With Minicast, you get:

- metal parts in nearly all castable metals and alloys
- dimensional tolerances as close as plus/minus 0.001″ per inch.
- cross-sectional thickness as low as 0.020.
- exceptional surface finish.
- complex configurations.
- the economy of production runs up to 50,000 per day.

And, for the first time, the Minicast process gives you these features at *only pennies per part.*

Get the complete story . . .
Write for this new descriptive brochure . . .
It's free of course.

ENGINEERED PRECISION CASTINGS

Casting Engineers, Inc.
2323 NORTH BOSWORTH AVENUE
CHICAGO 14, ILLINOIS

For more information, turn to Reader Service card, circle No. 499

Education on materials

To the Editor:

Your editorial "Let's Have Better Education on Materials," in the June issue was very thought provoking and championed an important cause. In ten years of engineering experience, I have yet to find a single engineer with the comprehensive knowledge of materials which you are advocating. Our age of specialization shows very clearly here—we have experts on metals, plastics, ceramics, and other specialized fields, but no one person has a reasonable working knowledge of the properties of all these materials. Even the various handbooks give very poor coverage in this field. Your magazine has probably done more to advance this compilation of materials properties than any other source.

Now we come to the problem at hand, i.e., how to impart this knowledge to the engineering student? Should all engineering graduates have the same knowledge of materials? I think not. Perhaps the mechanical engineer needs the most comprehensive knowledge. The chemical engineer might be next in line, followed by the civil, metallurgical, aeronautical and electrical engineer.

Shall the course cover only properties of materials or shall it include fabrication and uses? If we attempt to cover every facet, the course becomes too unwieldy. The reduction in course content must be made along curriculum lines. Another possibility is that of instituting a new diploma program—Materials Engineering. Many industries have a man, or group of men, with this title. Their backgrounds vary greatly but are generally strongest in the metallic materials.

Assuming that the problems of course content could be solved, it then becomes necessary to obtain someone to teach the course. If qualified men exist, they are scarce and able to command a high salary in industry difficult for an educational institution to match.

I hope that this criticism will not discourage the promotion of your idea, for surely it is a most worthy one. Rather, may the pointing out of the existing problems speed their solution.

EUGENE A. STACK
Materials Engineer
Thiokol Chemical Corp.
Reaction Motors Div.
Denville, N. J.

Search for a nonmetallic

To the Editor:

In our plant we manufacture glass television picture tubes. These tubes consist of a glass panel, which serves as the picture screen to the viewer, a glass funnel behind the panel, and a glass neck which houses the electron gun. The problem in this

"I get B&W Mechanical Tubing tailored to the job

As a shop superintendent, I'm sold on B&W. Because B&W Mechanical Tubing comes matched to our needs we've increased production and cut costs."

B&W furnishes a wide selection of mechanical tubing with properties that make it suitable for subsequent fabrication into an infinite variety of hollow cylindrical parts and products. You can usually select a tube with a diameter and wall thickness so close to the dimensions of the final product that machining and finishing costs are subsequently reduced and sometimes virtually eliminated.

B&W Mechanical Tubing not only provides the properties needed in the finished product but also makes possible easy fabrication and a more simplified and improved design. Checking with Mr. Tubes, your B&W specialist, when your product is in the design phase can save you vital production costs.

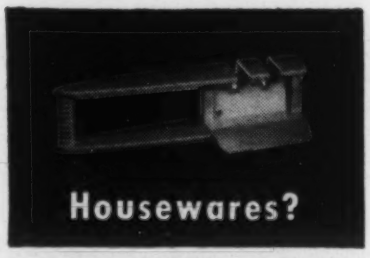
Write for Bulletin TB-347, The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

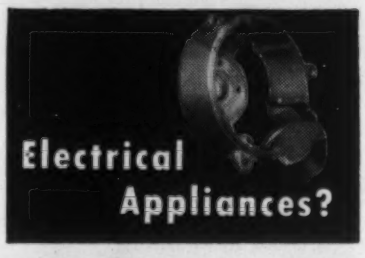
TA-8023-M4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

For more information, turn to Reader Service card, circle No. 402

What are your zinc or aluminum die casting needs...





ADVANCE know-how in Zinc and Aluminum die casting design, engineering and production covers a wide range of component part needs from small camera parts...

...to engine cylinders

Moreover, ADVANCE often solves a product sales problem by alert die casting engineering and skills which smooth-up product lines and appearance while at the same time improving casting cycles and lowering part costs.

That is why ADVANCE Zinc and Aluminum die cast parts are important components everywhere in home appliances, office equipment, power tools, gas engines, cameras, surveyors' instruments, electric motors and control devices.

Consult ADVANCE about your die cast parts problems . . . and write for folder "YOUR DOORWAY to Certified Zinc and Precision Aluminum Die Castings."

These symbols are your assurance of highest quality control of zinc and aluminum alloys under ADCI standards.

38 years of service to industry.

ADVANCE TOOL AND DIE CASTING CO.

3770 N. Holton Street
Milwaukee 12, Wisconsin

For more information, turn to Reader Service card, circle No. 424

instance concerns the operation in which the glass neck is fused to the glass funnel. In sealing the neck to the funnel, the neck is loaded onto a spindle and the funnel is inverted and set in a ring above the neck. The machine is automatic and once actuated follows a prescribed cycle during which the neck is sealed to the funnel.

The specific problem concerns the bottom ring that supports the funnel during the neck sealing operation. The bottom ring is contoured to fit the shape of the funnel. At the present time we are using Dow 301 material in an attempt to avoid glass-to-metal contact, but this material is not satisfactory because of the high coefficient of friction between the hot glass (340 F) and the 301 material. Cast iron contoured rings have been tried and produce excellent results, but because of the possibility of producing checks in the glass from the cast iron we are seeking a nonmetallic material that will operate at these temperatures (300-360 F) with a coefficient of friction similar to that of cast iron to glass.

LESTER O. SUNDLING
Corning Glass Works
Corning, N. Y.

A tetrafluoroethylene (Teflon) surface against the glass might solve the problem. This might be a TFE gasket inside the cast iron contour ring, or it might be more practical to have the ring itself made of TFE, possibly a reinforced composition.

Cold extrusion of steel

To the Editor:

Can you furnish the names of several manufacturers engaged in the cold extrusion of steel? Also, what issues describe the process?

ARTHUR M. SHRAGER
Brooklyn, N. Y.

The only custom producer of cold extrusions from steel of whom we are aware is Heintz Mfg. Co. of Philadelphia. Some of the automobile companies are producing such extrusions but, as far as we know, only for their own use. The process was described in our manual "Impact (Cold) Extruded Parts" which appeared in MATERIALS & METHODS, *Aug '55.*

Foam plastics

To the Editor:

In the excellent review article, "How Polyether Foams Compare," in M/DE, Mar '58, mention is made on pp 135 and 136 of phenolic and urea formaldehyde foams. We want to secure experimental quantities of both. Will you kindly furnish the names and addresses of manufacturers?

W. P. TER HORST
Pikesville, Md.

Our manual "Foam Plastics" contains the requested list and a copy has been mailed to Mr. Ter Horst.

Selection Factor	Self-Luminous Coatings ↓	vs	Conventional Light Sources ↓
Equipment Space	Very little space required		Wires, bulbs, batteries, etc., requiring relatively large amount of space
Maintenance, Reliability	No maintenance required because of the long life and self-contained nature of the light source		Constant maintenance required because of comparatively complex nature of equipment
Temperature Limits	None for practical purposes		Batteries can fail or become expended due to temperature extremes
Useful Life	From 2 to over 5000 yr, depending on isotope used		Components break down in relatively short time
Operating Hazards	Radiological danger can be prevented by use of suitable shielding		None
Cost	Initial cost is comparatively high. However, higher cost may be offset by longer life and maintenance-free operation		Low initial cost. However, life is short and maintenance is needed
Availability	Use limited by allocation of radioactive materials from AEC. Also, military requests have precedence over commercial applications		No restrictions

This table shows the advantages of

Self-Luminous Materials

Now available in limited quantities are radioactive coatings that glow in the dark without need for external excitation. This article describes the major materials that are available and tells where they can be used.

by Joseph L. Seminara, *Picatinny Arsenal*

■ In many applications, particularly military equipment, it is often quite difficult to find a practical source of illumination. A product that has to rely for its lighting on a remote or self-contained source of electricity is limited by the reliability, size and weight of the power source and associated equipment. Any one of a number of failures, even a bulb failure, can cause a lighting breakdown. In many cases these problems can be eliminated by using radioactive self-luminous materials which are not subject to breakdown, are light in weight, and require no maintenance.

What they are

Radioactive self-luminous materials are composed basically of a radioactive material combined with a phosphor. Depending on composition, they can be used in the form of a coating (the most popular form), a gas or a solid. The radioactive materials emit alpha and beta particles which strike the phosphors and produce visible light. Thus, the materials are self-luminous in that they require no external source of energy for activation. They differ from fluorescent and phosphorescent materials which must be exposed to light or other excitation in order to glow.

Where they are useful

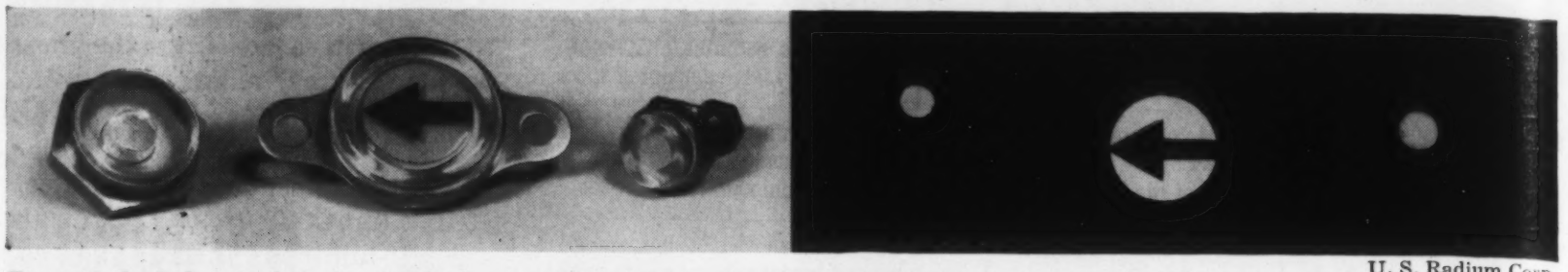
The major advantages and disadvantages of self-luminous coatings are compared briefly with those of conventional light sources at the left. A self-contained source of illumination is desirable in a number of applications where:

Conventional light sources are impractical—Such a situation can arise if the unit to be illuminated is relatively small and space is at a premium (e.g., instrument dials and small markers). There are also a number of purely mechanical devices such as alarm clocks and pressure gages which are inconvenient to illuminate. Valuable space is taken up by wires, batteries and bulbs. In such cases a radioactive source of illumination is particularly valuable since it is self-contained and takes up a minimum of space.

Reliability is needed—This is an important factor, especially in military applications where a dependable power source that can withstand vigorous environments is needed. In contrast to battery power, a radioactive source of illumination is not affected by temperature extremes.

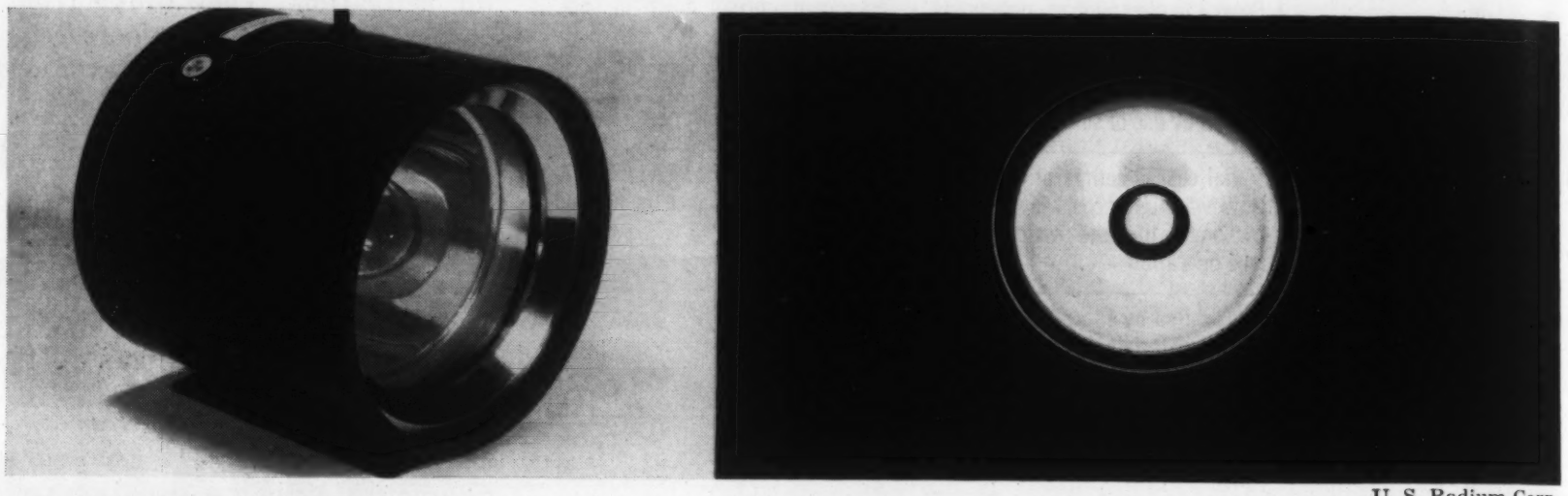
Low maintenance is required—Conventional light sources require maintenance when bulbs burn out, wires become disconnected, batteries become expended, or when controls break down. In contrast, self-luminous sources can provide maintenance-free operation for years. In fact, in many cases the illuminant has longer life than the product in which it is used.

Three Uses of Self-Luminous Coatings



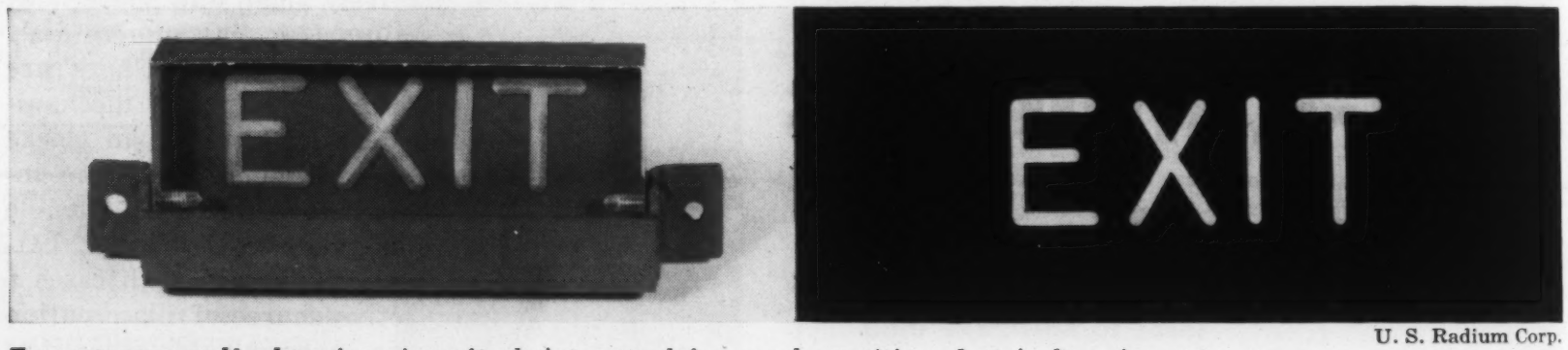
U. S. Radium Corp.

Escape hatch marker *is visible in complete darkness and does not require any external source of energy.*



U. S. Radium Corp.

Signal lamp *is available in different colors and is visible at over 1500 ft.*



U. S. Radium Corp.

Emergency exit sign *for aircraft obviates need for crash-sensitive electrical equipment.*

Special properties are needed—Self-luminous materials are particularly valuable in military applications. Because of the danger of premature detonation, an electrical light source cannot be used in some types of equipment that operate close to explosive elements. In such cases, self-luminous sources can supply illumination for night operation of controls and marking of panel labels.

Some disadvantages

Radiological danger — Radioactive materials are dangerous to handle, and a good deal of research has been devoted to making these self-luminous materials safe for the user. All of the materials currently available can be rendered harmless by the use of suitable (lead, clear plastic or glass) shielding. In fact, a self-luminous paint (discussed later) has been developed which is claimed to require no shielding at all.

Availability—All of the radioactive self-luminous materials are controlled and allocated by the Atomic Energy Commission. The materials are not available to all individuals but are usually allocated to specialized companies (such as U. S. Radium Corp. and New England Nuclear Corp.) that are equipped to safely handle and process the materials.

The quotas currently allocated to users of self-luminous materials are insufficient to meet demands. Ordinarily, military applications take precedence over commercial applications. However, there are hopes that restrictions will soon be eased and enough materials will be made available for all military and commercial applications.

Types and properties

A good deal of research has been devoted to finding the right combination of radioactive substances and phosphors to produce

light of sufficient brightness over a useful period of time.

Radium—The first practically successful self-luminous sources utilized radium as the activating medium. An example of its use is the greenish-blue light which can be seen in the dark on the markings of watches and clocks. However, radium-excited phosphors have not proved widely applicable for two main reasons: 1) the material is hard to handle because it emits extremely dangerous radiation (also, ingestion of even minute quantities is fatal), and 2) radium alpha particles destroy the phosphor crystals very quickly, causing a rapid loss in the brightness of emitted light.

Fission products—The principal reason for the early use of radioactive radium as a light source is that the material occurs naturally. However, with the advent of the pile reaction it is now feasible to produce, by artificial means, radioactive fission products such as strontium-90, krypton, thallium, promethium and tritium (see table below).

All of these materials have a different luminous life. The luminous life of a radioactive luminous material is approximately directly proportional to the half-life of the radioisotope. Half-life is the length of time in which one half of the nuclei decay from the original isotope form to another form. The half-lives of the materials listed vary from 2 to 5720 yr.

The materials also differ in the kind of radiation they emit and thus in the amount of shielding needed to make them harmless. For example, strontium-90 emits both beta and gamma rays, whereas tritium emits just beta rays. The gamma radiation is quite penetrating; the beta rays are much less penetrating and damaging. Since strontium-90 emits gamma radiation it is more dangerous and requires more shielding than tritium. As shown in Table 2, the amount of shielding required can be as thick as $\frac{3}{8}$ in. Thus, this factor can be quite important in determining if a particular radioisotope can be incorporated in a specific design.

The table also shows the wide variation in light output of the self-luminous materials. In some applications a brightness of 20 μL is sufficient; in other designs 800 μL (the maximum brightness presently available) may be required. A good deal of effort is currently being expended on improving materials and it is expected that brightness levels can be raised somewhat.

Tritium—Tritium is presently quite popular as a self-luminous light source. Its popularity is due to: 1) the very small amount of shielding required for protection, 2) its comparatively long half-life of 12.5 years, and 3) its relatively high brightness level.

Solid or gaseous forms of tritium can be placed in capsules for illumination purposes. There are advantages and disadvantages to using either form. If a capsule containing gaseous tritium is broken in a well ventilated area, it is likely that the gas will escape and dissipate harmlessly. Such dissipation cannot occur if breakage occurs when using solid tritium. On the other hand, designs utilizing gaseous tritium are likely to take up more space. The solid form of tritium is usually adequate if the container is well built and if breakage conditions are not likely to be encountered.

In addition to the above forms a tritium paint has been developed which is claimed to require no shielding whatsoever. This paint consists of the tritium isotope together with a phosphor, solvents and adhesives. Brightness levels of up to 60 μL can be obtained, and it is expected that levels of 75 to 150 μL will be attained in the future.

Formal AEC tests must be performed to insure that radiological safety standards are complied with before the unshielded radioactive paints can be placed on the market. It is expected that these tests will be scheduled during 1958.

Selection factors

The following factors must be considered when selecting a self-luminous light source:

1. The brightness required to illuminate an object at a given distance.
2. Color required.
3. Decay characteristics of the radioisotope as expressed by its

PROPERTIES OF SELF-LUMINOUS MATERIALS

Radioisotope	Symbol	Half-Life, yr	Shielding Required, in.[a]	Max Surface Brightness Attainable, eff μ L[b]				
				Blue	Green	Yellow	Orange	Red
Tritium (solid)	H3	12.5	0.01	125	400	400	125	50
Tritium (gas)	H3	12.5	0.01	200	800	—	100	200
Tritium (paint)	H3	12.5	None	10	60	40	5	10
Krypton	Kr85	9.4	$\frac{1}{8}$	250	800	800	250	100
Strontium	Sr90	25.0	$\frac{3}{8}$	50	400	200	50	30
Promethium	Pm147	2.36	$\frac{1}{16}$	5	30	15	5	3
Thallium	Tl204	2.7	$\frac{1}{8}$	15	70	50	15	10
Carbon	C14	5720.0	$\frac{1}{16}$	1.5	3	3	1.5	1

[a]Thickness is independent of shielding materials used. Typical shielding materials are clear plastic, glass and lead.
[b]A lambert (L) is the luminance of a perfectly reflecting and diffusing surface 1 cm away from a 1-candlepower source. One lambert equals one million microlamberts (μL). If the candlepower source has a color temperature of 2360 K, the unit is known as an effective microlambert (eff μL).

half-life value (see table, p 91).

4. Expected life of the component being designed.

Brightness—The brightness required of a self-luminous source is, of course, dependent on the distance at which the illuminated object will be viewed. For example, the brightness required for a theater exit sign will be considerably greater than that required for the markings on a wristwatch.

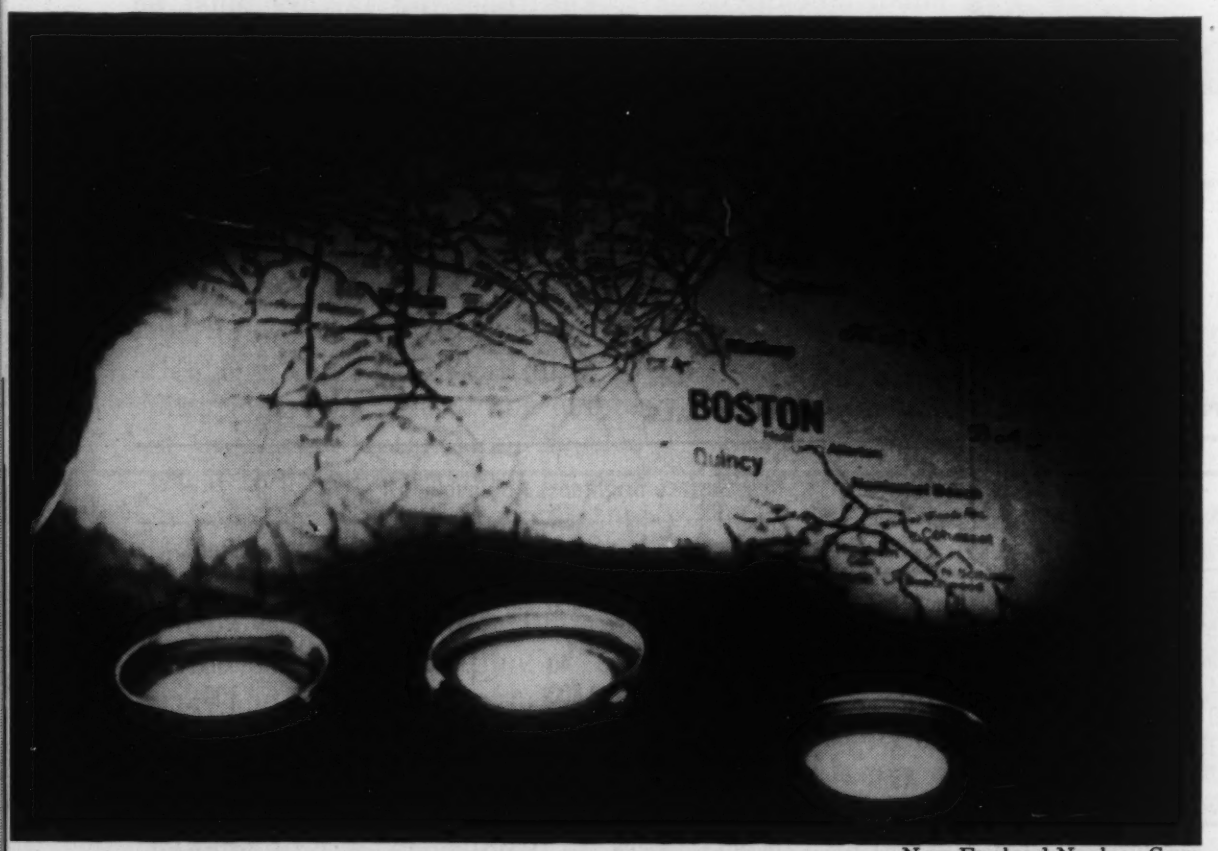
Quite often designers specify a brightness which is much greater than that actually needed. Some research and field testing is necessary to establish the minimum brightness level required for any given application. The Naval Research Laboratory has conducted much of the original research on this subject, particularly in determining the distances at which deck markers can be seen. The NRL has found, for example, that a 1¾-in. radioactive green marker with a brightness of 72.5 eff μL can be detected at a maximum distance of 950 to 1000 ft. The maximum distance at which the green color can be distinguished is 150 ft.

Color—The color of self-luminous light sources depends on the phosphor used and the kind and amount of impurities it contains. As shown in the table on p 91, not all colors can be obtained. The most commonly used are the blue-greens and yellow-greens.

Some colors can be detected more easily than others at night at a distance. On the other hand, other colors may prove best for illuminating labels which must be read at night or under low ambient illumination.

Life—The designer must take into account the decrease in luminosity with time in proportion to the half-life of the isotope. If we start with a strontium source with a half-life of 25 years and an initial brightness of 60 μL, in 25 years the brightness will drop to 30 μL. Thus, conversely, if we wish to maintain a minimum brightness of 30 μL after 25 years, the initial brightness must be 60 μL.

Cost—The cost of self-luminous materials depends on a number of factors such as the required brightness, size of the area to be illuminated, the specific radioisotope used, complexity of markings, and the number of units to be illuminated. In many cases the higher cost of the materials compared to conventional lighting sources can be offset by the reduced maintenance required.



New England Nuclear Corp.

***Flashlight** utilizing tritium can be used for years without need for maintenance or replacement.*

Applications

It is axiomatic that military equipment and personnel must function effectively at night. One of the first applications for self-luminous sources was made by the Navy. Through the use of self-luminous deck markers, personnel can orient themselves with respect to exits, entrances, deck stations and equipment under conditions of extreme darkness. Other military uses now in use or under development include:

1. Identification of different types of ammunition.
2. Personnel identification by different colors.
3. Unit identification in combat situations.
4. Light source in signaling systems.
5. Life raft marker.
6. Light source for underwater demolition teams.
7. Radioactive flashlight for map reading, etc.

The materials are also being considered for illuminating scales, counter drums, level vials, reticles and control panels. For example, it is difficult to use conventional light sources to illuminate the scale on a gunner's quadrant, but good visibility is provided by a self-luminous material directly on the scale itself.

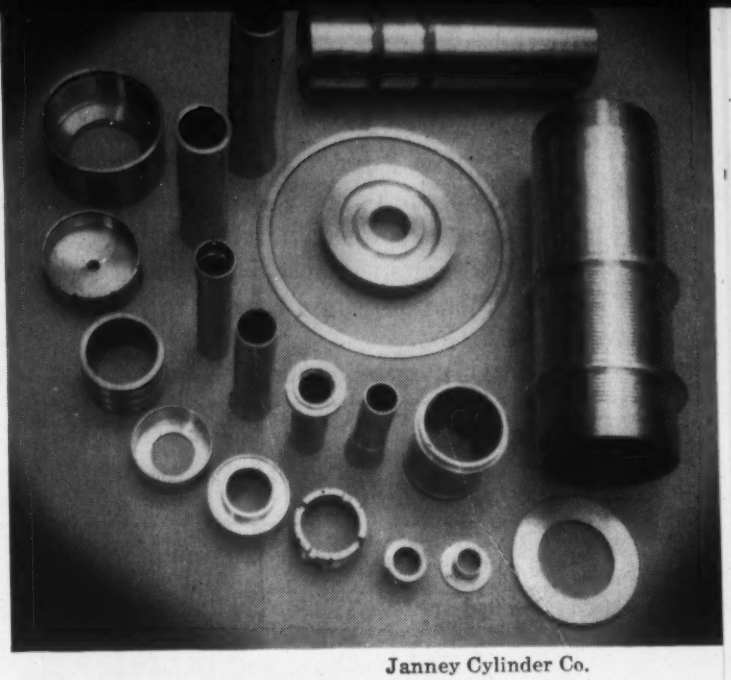
Most applications of self-luminous light sources developed to date have been for military equipment. However, a number of commercial applications are under development.

Railroad companies are currently testing the use of self-luminous sources in warning lamps. These lamps are expected to eliminate the need for expensive cables and reduce the maintenance required with conventional electric lamps. Other suggested commercial uses include: exit signs and theater seat markings; darkroom orientation markers; and markings for keyholes, light switches, telephones, etc.

Shenango Furnace Co.

Here are some current uses →

Corrugating roll *used in paper manufacture is a cylinder centrifugally cast from bronze (87 Cu-6 Sn-3 Pb-4% Zn) for service under low temperature and pressure.*



Janney Cylinder Co.

Aircraft landing gear *parts, thrust washers, seal rings and gear blanks are typical of the parts that can be produced from centrifugally cast bronzes.*

Why and Where to Use

Centrifugal Castings

PART 2. NONFERROUS CASTINGS

by John L. Everhart, *Technical Editor, Materials in Design Engineering*

■ Nonferrous centrifugal castings are produced from copper alloys, nickel alloys, and tin and lead-base bearing metals. Only limited application of the process is made to light metals because it is questionable whether any property improvement is achieved; for example, differences in density between aluminum and its normal impurities are smaller than in the heavy metals and consequently separation of the oxides, a major advantage of the process, is not so successful.

Shapes, sizes, tolerances

As discussed in Part 1 for ferrous alloys, the external shapes of nonferrous centrifugal castings can be elliptical, hexagonal or fluted, as well as round. However, the greatest overall tonnage of nonferrous castings is produced in plain or semi-plain cylinders. The inside diameter of the casting is limited to a straight bore or one that can be machined to the required contour with minimum machining cost.

Nonferrous castings are produced commercially in o.d.'s ranging from about 1 in. to 6 ft and in lengths up to 27 ft. Weights of individual castings range from 8 oz to 60,000 lb.

Although tolerances on as-cast parts are about the same as those for sand castings, most centrifugal castings are finished by machining. An advantage of centrifugal casting is that normally only a small machining allowance is required; this allowance varies from as little as 1/16 in. on small castings to 1/4 in. on the o.d. of large diameter castings. A slightly larger machining allowance is required on the bore to permit removal of dross and other impurities that segregate in this area.

Copper alloys

A wide range of copper casting alloys is used in the production of centrifugal castings. The alloys include the plain brasses, leaded brasses and bronzes, tin bronzes, aluminum bronzes, silicon bronzes, manganese bronzes, nickel silvers and beryllium copper. The ASTM lists 32 copper alloys for centrifugal casting; in addition, there are a number of proprietary compositions that are regularly produced by centrifugal casting.

Most of these alloys can be cast without difficulty. Some trouble with segregation has been reported in casting the high leaded (over 10% lead) alloys. However, alloys containing up to 20% lead are being cast by some foundries, the requirements being 1) rapid chilling to prevent excessive lead segregation, and 2) close control of speed.

The mechanical properties of centrifugally cast copper alloys vary with the composition and are affected by the mold material used. Properties of some alloys

are given in Table 1. Centrifugal castings produced in chill molds have higher mechanical properties than those obtained by casting in sand molds. However, centrifugal castings made in sand molds have properties about 10% higher than those obtained on equivalent sections of castings produced in static sand molds. (Castings produced in centrifugal chill molds have properties 20 to 40% higher than those produced in static sand molds.) Table 2 compares the properties of several alloys cast in static and centrifugal molds.

The largest single use of centrifugally cast copper alloys is in bearings. Because of the flexibility of the process, bearings ranging in size from 1 to 15 in. o.d. can be produced economically in lots ranging from 50 to 5000 parts.

The aluminum bronzes, in addition to their bearing applications, are used for gears, connecting rods, slides and other machine parts, shifter forks, screw-down nuts in steel mills, and forming dies.

Because of their excellent resistance to corrosion by papermaking liquors, the tin bronzes are used for making suction rolls and corrugating rolls for paper production. Other uses of these

TABLE 1—PROPERTIES OF SOME ALLOYS USED FOR CENTRIFUGAL CASTINGS

Alloy ↓	Nominal Comp, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %	Compr Yld Str, 1000 psi	Brinell Hardness
COPPER ALLOYS[a] (see also Table 2)						
Leaded Red Brass	Cu 85, Sn 5, Pb 5, Zn 5	30	14	20	12	60
Tin Bronze	Cu 88, Sn 10, Zn 2	40	18	20	16.5	70
Leaded Tin Bronze	Cu 83, Sn 7, Pb 7, Zn 3	30	16	12	16	62
Manganese Bronze	Cu 65, Al 5, Fe 3, Mn 3, Zn 24	103	53	25	—	190
Manganese Bronze	Cu 61, Al 5.5, Mn 3, Fe 3.5, Zn bal	110	60	12	—	223
Aluminum Bronze	Cu 85, Al 11, Fe 4	75	30	12	—	146
Aluminum Bronze	Cu 78, Al 10, Fe 4, Ni 4, Mn 4	90	45	10	—	167
Nickel Bronze	Cu 85, Sn 10, Pb 2, Ni 3	45	25	18	—	75
Nickel Silver	Cu 65, Zn 15, Ni 12, Sn 2, Pb 6	34	17.5	25	—	50
Cupro-Nickel	Cu bal, Ni 20, Fe 1, Mn 1	75	55	10	—	—
NICKEL ALLOYS						
Nickel		45-60	20-30	15-30	—	80-125
Monel		65-90	32-45	25-50	—	125-150
S-Monel		120-145	80-130	1-4	—	275-350
H-Monel		75-115	45-80	10-20	—	175-250
Inconel		70-95	30-45	10-30	—	160-190
ACI Type HW	Ni 60, Cr 12	68	40	8	—	175
ACI Type HX	Ni 64, Cr 17	68	40	8	—	175

[a]Minimum properties.

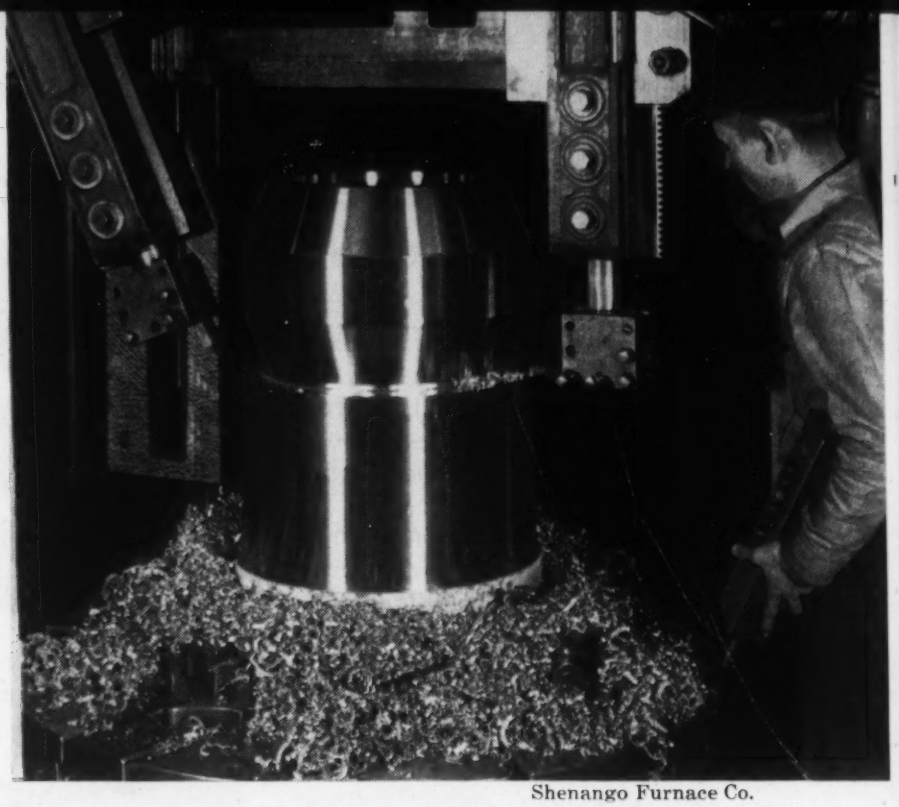
TABLE 2—PROPERTIES OF STATIC AND CENTRIFUGALLY CAST COPPER ALLOYS—A COMPARISON OF PROPERTIES

Nominal Composition, %						Casting Method	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elong (2 in.), %	Red. of Area, %	Brinell Hardness
Cu	Al	Fe	Sn	Zn	Pb						
90	10	—	—	—	—	Static	71	28	30	31	—
						Centrifugal	78	32	39	34	—
Bal	10.5	4	—	—	—	Sand	90	37	14	12	183
						Centrifugal	105	38	20	20	187
Bal	11.5	4	—	—	—	Sand	85	40	4	3.5	212
						Centrifugal	95	40	5	4.5	223
Bal	13	4.5	—	—	—	Sand	75	55	1.5	0.5	285
						Centrifugal	80	55	1.5	0.5	285
88	9	3	—	—	—	Static	79	29	40	40	—
						Centrifugal	88	32	40	42	—
86	10	4	—	—	—	Static	84	35	12	11	—
						Centrifugal	97	38	17	17	—
58	1	1	—	Bal	—	Static	72	26	30	30	—
						Centrifugal	78	33	37	38	—
61	5.5	3.5	—	Bal	—	Static	112	70	15	20	—
						Centrifugal	120	73	23	29	—
88	—	—	6	4	2	Static	41	21	39	32	—
						Centrifugal	49	21	61	40	—
88	—	—	8	4	—	Static	47	24	25	28	—
						Centrifugal	52	27	55	54	—

Source: *Edens and Klement* and Ampco Metal, Inc.

Shenango Furnace Co.

High pressure cylinder *bodies used in the tire industry are cast from 88 Cu-10 Sn-4% Zn bronze.*



Shenango Furnace Co.

Trunnion bearing *for use in heavy machinery is machined from a manganese bronze centrifugal casting.*

bronzes include high pressure cylinder bodies, aircraft bushings and valve liners. Manganese bronzes are used for gear blanks, hose nipples and trunnion bearings.

Brasses are used for rings and bushings of various types and textile engraving rolls. Nickel silvers are used for pressure-tight service in radio transmission equipment.

Other uses for the copper alloys are gears and gear blanks, impellers, sheaves, pulleys, manifolds, and aircraft cylinder liners and rings.

Nickel alloys

Centrifugal castings of nickel, monel, S-monel, H-monel, G-nickel, silicon nickel, Inconel and silicon Inconel are commercially available in cylindrical tubes. Centrifugal castings are also produced from the heat resisting alloys 60 nickel-12% chromium and 66 nickel-17% chromium.

Minimum mechanical properties of many of these alloys are given in Table 1. No data were found to indicate the improvement in properties resulting from centrifugal casting instead of static casting. However, these alloys should behave like other materials and show improved density with accompanying improvement in mechanical properties.

The nickel alloys are employed for service under severe corrosion, abrasion and galling conditions. Applications include shaft sleeves for pumps handling salt water, sleeves for Jordan machines, impellers and similar parts, furnace rollers and other parts subjected to high temperatures.

Bearing metals

Centrifugal casting is a standard method of producing lined bearings. Steel cylinders after being cleaned, pickled and tinned are rotated while tin or lead-base bearing alloys are cast into them. The composite cylinder is then cut lengthwise, machined and finished into split bearings.

Lined bearings are used in mining machinery, car journals, machine tools, diesel engines, automotive engines, tractors, trucks and heavy machinery.

Acknowledgment

The assistance of the following organizations in the preparation of this article is gratefully acknowledged:

Ampco Metal, Inc.
Centrifugally Cast Products Div., Shenango Furnace Co.
Duraloy Co.
International Nickel Co.
Janney Cylinder Co.
National Bearing Div., American Brake Shoe Co.
Sandusky Foundry and Machine Co.

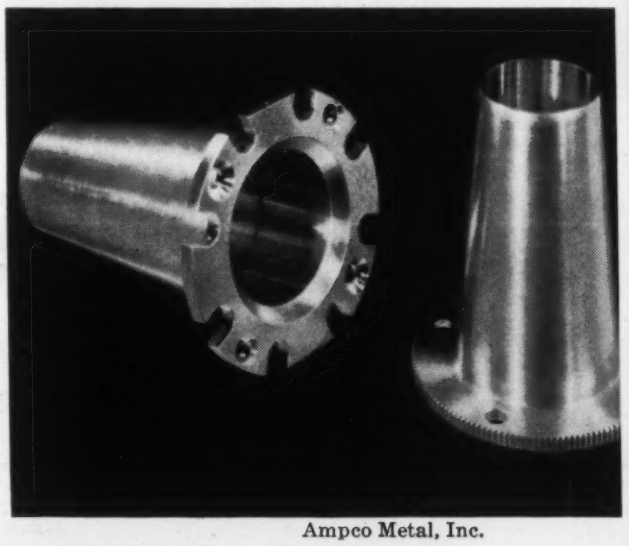
References

Bremer, E., "Foundry Specializes in Centrifugal Castings," *Foundry*, May '55, p 130.

Edens, W. W., and Klement, J. F., "The Influence of the Centrifugal Process on the Physical Properties of Some Non-Ferrous Alloys," *Trans. Am. Foundrymen's Soc*, 1944-45, p 393.

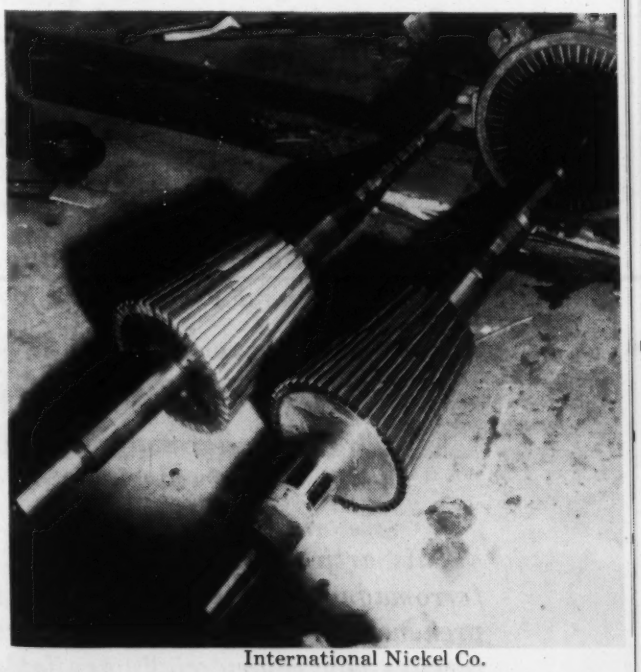
Metals Handbook, 1948 Ed., American Society for Metals, Cleveland, Ohio, 1948.

Mohler, J. B., "Centrifugal Casting of Sleeve Bearings," *Foundry*, Dec '54, p 102.



Ampco Metal, Inc.

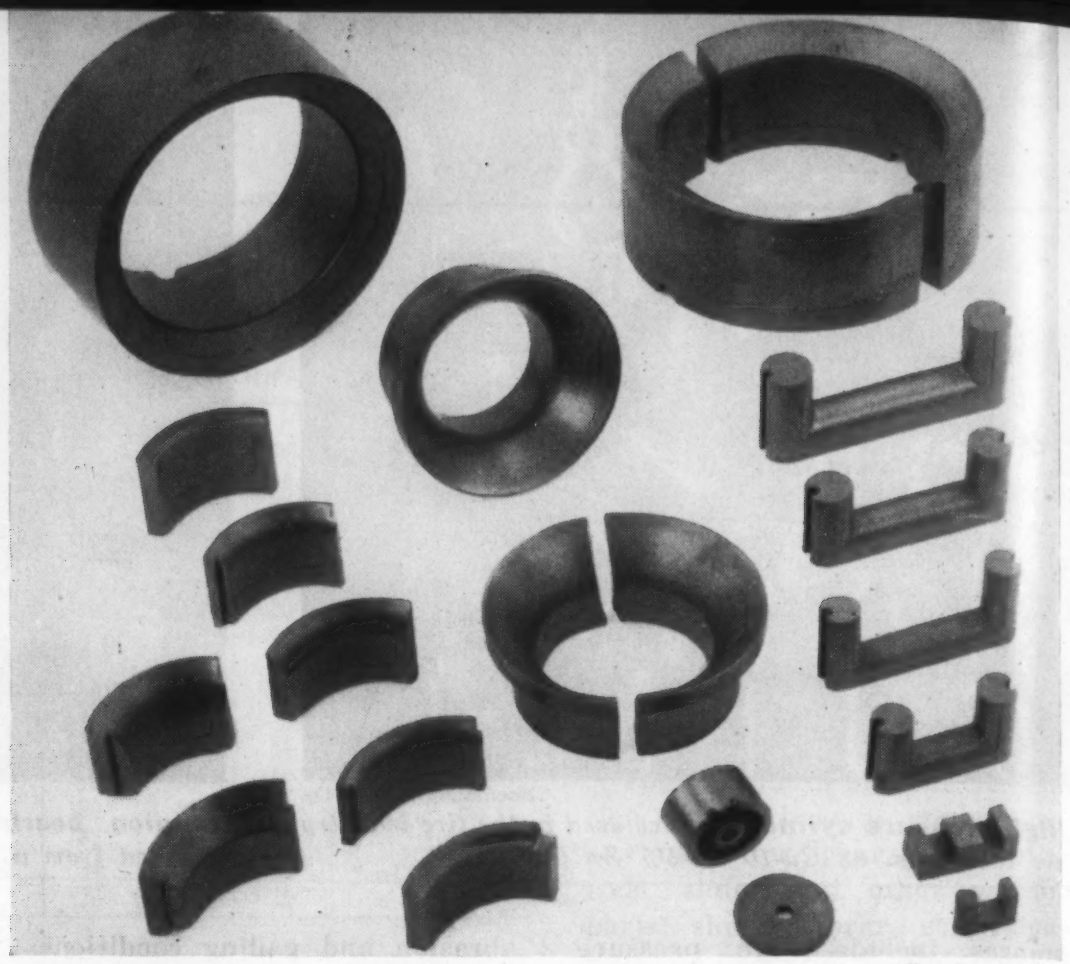
Controllable-pitch propeller bushings *cast from aluminum bronze illustrate internal contours obtained with minimum machining.*



International Nickel Co.

Sleeves *for machine that grinds raw asbestos are cast from S-monel for high wear resistance.*

A Guide to . . .



Typical shapes *of commercial ferrite bodies.*

Allen-Bradley Co.

Ferromagnetic Ceramics

PART 1 | *How ferrites work*
Properties of soft ferrites

by George Economos, *Massachusetts Institute of Technology*

Types of Ferrites

Commercial ferromagnetic materials, or ferrites, can be classified into four general categories:

1. **Soft ferrites,** *the oldest type, useful for their initial magnetization characteristics in both the initial permeability and maximum permeability ranges.*
2. **Square loop or switching ferrites,** *useful for their square or rectangular hysteresis loop characteristics.*
3. **Microwave ferrites,** *the most recent type, useful for their behavior at high frequencies.*
4. **Hard or permanent magnet ceramic materials,** *which, though not actually ferrites, are closely related to them.*

This article discusses the soft ferrites and explains the nature of ferromagnetic materials and how they work. It contains the first comprehensive compilation of property data to be published on the soft ferrites now commercially available. Part 2 next month will discuss the newer materials.

■ The development of ferromagnetic ceramic materials has provided radical improvements in design of electronic equipment, and in many cases has resulted in the development of completely new types of equipment. Among the many devices making use of ferrites are television sets, memory devices and computers, antennas, magnetic switches, recorders and wide band transformers.

How ferrites work

Their structure—The ionic arrangement of the ferrite crystal is important in that the magnetic response is directly related to the cation (positively charged particle) distribution. The unit cell can be visualized as a cube, containing 32 oxygen anions (negatively charged particles) stacked in a face-centered arrangement. Two types of interstitial sites

exist in this type of packing: tetrahedral positions and octahedral positions. Of a total of 96 such sites only 24 are occupied: 8 tetrahedral and 16 octahedral.

The locations of the cations in these sites generally differentiate the nonmagnetic spinels from the ferromagnetic spinels, or ferrites. In the nonmagnetic spinels a "normal" ionic distribution exists in that the divalent cations (Mg^{+2}, Zn^{+2}, etc.) are in the tetrahedral sites and the trivalent cations (Al^{+3}, Fe^{+3}, etc.) are in the octahedral sites. (This situation can be visualized in a unit cell where there are eight formula weights in the compound, such as $Mg_8Al_{16}O_{32}$.)

In the ferrites, on the other hand, the cations are in the "inverse" positions, or some modification thereof. Using a unit cell of magnetite as an example, the divalent cations (8 Fe^{+2}) occupy half of the octahedral sites, while the remaining eight octahedral and the eight tetrahedral sites are filled with trivalent cations (16 Fe^{+3}).

Ferromagnetism — The early problems of understanding the magnetic behavior of ferrites was solved for the most part by *Neel* whose theory predicted observed magnetic behavior almost exactly. The magnetic spin vectors, i.e., directions of magnetic force, are parallel in a given crystal site and antiparallel in different sites. Because of 1) the unequal number of these sites (two octahedral sites for each tetrahedral site), and 2) the magnitude of the magnetic moment of the cations and their distribution, the nonparallel moments do not completely cancel out, leaving a net magnetic moment. Tables 1 and 2 show the magnitude of the magnetic moment of various cations and the origin of the net moment in some inverse ferrites, comparing calculated and observed values.

Thus, the ultimate magnitude of the magnetic moment of a ferrite is controlled by the crystallographic structure and the cations involved. The ultimate moment can be controlled to a degree by altering the structure and composition of the ferrite material.

Hysteresis loop characteristics —The familiar hysteresis loop is caused by the application of sinusoidal varying electrical fields to the ferromagnetic ferrite. Application of a small field to a fer-

Ferromagnetic Materials

What they are

Ferromagnetic materials are derivatives of magnetite (Fe_3O_4) which occurs naturally in iron ore deposits. They belong to a larger class of minerals called spinels ($MgAl_2O_4$). Although the term "ferrite" has been used by the metallurgist to refer to alpha iron, by common usage, it has become the term used to describe ferromagnetic materials. The term "ferrospinel" would actually be more appropriate because it more exactly describes the material.

How they're made

The simplest and most widely used method of producing ferrite compounds is by thoroughly mixing high purity iron oxide (Fe_2O_3) with one or more equally pure divalent oxides, such as nickel oxide (NiO), magnesia (MgO) or zinc oxide (ZnO). The mixture is then calcined or reacted at 1475 to 2200 F. The resulting "sinter cake" is then ground to a fine particle size, mixed with lubricants and binders, and pressed into the desired shapes. Sintering and densification are achieved at temperatures of 2200 to 3000 F, depending on the composition and properties desired.

This description is of the simplest case. Actually, the mixtures may deviate considerably from such ideal stoichiometric compounds. The processing operations may also consist of complex cycles, depending on the manufacturer. There is still a great deal of "potters' art" in obtaining the desired final product, both electrically and physically. Also, the purity and uniformity requirements of the raw materials are extremely high. Both the raw materials suppliers and the ferrite manufacturers have gone far in meeting these high requirements.

TABLE 1—CHARACTERISTICS OF CATIONS

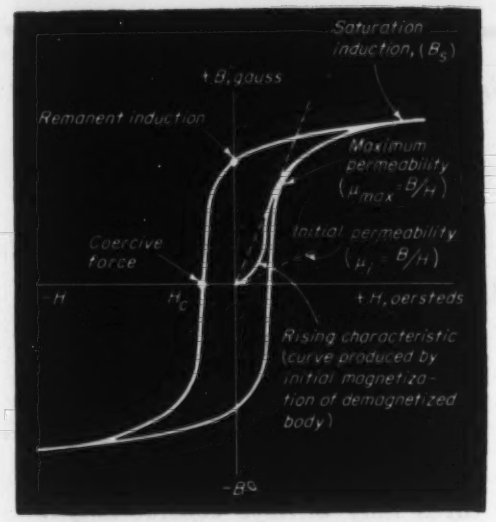
Cation	3-d Electrons	Spin Alignment	Net Moment[a] (Bohr magnetons)
Mn^{+3}	4	↑↑↑↑	4
Fe^{+3}, Mn^{+2}	5	↑↑↑↑↑	5
Fe^{+2}, Co^{+3}	6	↑↑↑↑↑ ↓	4
Co^{+2}	7	↑↑↑↑↑ ↓↓	3
Ni^{+2}	8	↑↑↑↑↑ ↓↓↓	2
Cu^{+2}	9	↑↑↑↑↑ ↓↓↓↓	1
Cd^{+2}, Zn^{+2}, Cu^{+1}	10	↑↑↑↑↑ ↓↓↓↓↓	0
Mg^{+2}	0	—	0

[a]Moments are simple approximations, rather than based on quantum mechanics.

TABLE 2—MAGNETIC MOMENTS IN FERRITES[b]

Ferrite	Cation Arrangement		Spin Arrangement		Moment (Bohr magnetons)	
	Tetrahedral	Octahedral	Tetrahedral	Octahedral	Calculated[a]	Observed
$NiFe_2O_4$	Fe^{+3}	$Fe^{+3}Ni^{+2}$	↑↑↑↑↑	↓↓↓↓↓ ↑↑	2	2.3
$CoFe_2O_4$	Fe^{+3}	$Fe^{+3}Co^{+2}$	↑↑↑↑↑	↓↓↓↓↓ ↑↑↑	3	3.7
Fe_3O_4	Fe^{+3}	$Fe^{+3}Fe^{+2}$	↑↑↑↑↑	↓↓↓↓↓ ↑↑↑↑	4	4.1
$MnFe_2O_4$[c]	Fe^{+3}	$Fe^{+3}Mn^{+2}$	↑↑↑↑↑	↓↓↓↓↓ ↑↑↑↑↑	5	4.6-5.0

[a]Moments are simple approximations, rather than based on quantum mechanics.
[b]Source: *Gorter.*
[c]Recent studies indicate that this ferrite is nearly normal, not inverse as shown here.



***Magnetic** hysteresis loop characteristics.*

rite produces a reversible change in the size of those domains oriented in directions most common to that of the field. (Recent studies indicate that the spin vector rotation mechanism can also contribute materially to this effect.) An increase in the applied field causes the domain walls to irreversibly move over imperfections, such as voids and impurities, in the lattice. Further increases will finally cause an alignment of all the spin vectors into the direction of the applied field, resulting in a state of maximum magnetization, or saturation magnetization, shown as B_s in the accompanying sketch.

Removal of the applied field permits newly formed domains to achieve a new stable configuration quite different from the original demagnetized state. The remaining inductance is called the remanence (B_r). The field required to return magnetization to zero is called coercive force (H_c). Reversal of the applied field causes the magnetization to follow the same sequence as before, but ending up at the remanent state in the reverse direction ($-B_r$).

Very little use is actually made of the complete hysteresis loop, with the exception of applications of square loop ferrites. Most applications of ferrites utilize the low field segment of the initial magnetization curve, which indicates initial permeability (μ_i) as determined by the ratio of inductance (B) to coercive force (H) as the latter approaches zero; and the higher field portion of the curve which indicates maximum permeability (μ_{max}) as represented by the slope of a line drawn from the zero axis to the knee in the initial curve.

TABLE 3—APPLICATIONS OF SOFT FERRITES

Type of Component	Typical Frequency	Characteristic Sought	Favorable Ferrite Properties
LINEAR B-H (low flux density)			
Filter Inductors	100 kc	High Q, precision, stability, low modulation	High μQ, low hysteresis, convenient core shapes
IF Transformers	465 kc	High Q, stability, adjustability	High μQ
Antenna Cores	1000 kc	Moderate Q, stability	High μQ, rod shapes
Wide Band Transformers	To 15 mc	Reproducibility of transmission characteristics	High μ, low losses, assembled core structures
Adjustable Inductors	Various	Adjustment $\pm 20\%$	High μ
Tuners	Various	Adjustment 10:1	Various mechanical structures available, μ variation in d.c. field
Miniature Inductors	Various	Moderate Q, small size	Cup shapes
Loading Coils	Voice	Stability, low modulations, low leakage flux	High μQ
NONLINEAR B-H (medium to high flux density)			
Flyback Transformers	15-100 kc	Low loss, moderate size	—
Miniature Transformers	Pulse	Small size, easy mounting	High μ, cup shapes
Suppression Beads	—	High resistive impedance	High loss above critical frequency
Recording Heads	—	—	Mechanical rigidity, low loss

Source: Adapted from *Owens*.

Improving magnetic characteristics

A number of steps can be taken during the production of ferrite bodies to improve magnetic characteristics of the material. Increasing density improves the material's behavior by increasing inductance (B) and initial permeability (μ_i) and lowering coercive force (H_c). Although fluctuations in density do not alter the magnetic moment (this being an inherent chemical and crystallographic property of the material), increasing the density increases the amount of material occupying a given volume, thus increasing inductance. Increasing density also decreases voids and imperfections, thus permitting easier movement of domain walls through the crystallites, providing higher initial and maximum permeability and lower coercive force.

Other ways in which these important properties can be improved include decreasing impurities and increasing homogeneity of ferrite bodies.

Soft ferrites

The majority of the ferromagnetic materials used today are soft ferrites and are used for radio antennas, filter and adjustable inductors, deflection yokes, recording heads and wide band transformers.

Materials with initial permeabilities of over 6000 g per oersted are available, and resistivities as high as 10^8 ohm-cm (extremely important in the "Q" of the material) have been reported. Room temperature saturation induction

Properties of Typical Commercial Soft Ferrites

GENERAL CERAMICS CORP. (Ferramic)

Grade ↓	μ_i (1 mc), g/oe	μ_{max}, g/oe	B_{max} (25 oe), g	B_r, g	H_c, oe	Temp Coef of μ_i, %/°F	Loss factor, $1/\mu_i Q$			T_c, F
							50 Kc	1 Mc	5 Mc	
C	250	1100	4200	2700	2.1	0.22	—	7×10^{-5}	8×10^{-4}	626
D	410	1030	3100	1320	1.0	0.17	—	5×10^{-5}	1.2×10^{-3}	329
E	750	1710	3800	1950	0.65	0.14	—	8×10^{-5}	2×10^{-3}	320
G	410	3300	3200	1050	0.25	0.72	—	8×10^{-5}	7.5×10^{-4}	320
H	850	4300	3400	1470	0.18	0.36	—	3×10^{-4}	1.5×10^{-3}	302
H-1	550	3800	2800	1500	0.35	0.44	—	4×10^{-4}	1×10^{-3}	257
I	900	3000	2000	700	0.30	0.17	—	3×10^{-4}	5×10^{-3}	158
N	200	500	3000	2300	0.50	0.08	—	3.5×10^{-5}	1.2×10^{-4}	554
O-1	800	4250	4250	1600	0.24	0.33	1.5×10^{-5}	—	—	374
O-2	1100	3100	4500	1600	0.30	0.33	1.1×10^{-5}	—	—	374
Q	125	400	3300	1800	2.1	0.06	—	2×10^{-5}	5×10^{-5}	662

HENRY L. CROWLEY & CO., INC. (Croloy

Grade ↓	μ_i (1 mc), g/oe	μ_{max}, g/oe	B_s, g	B_r, g	H_c, oe	Temp Coef of μ_i, %/°F	Loss Factor, $1/\mu_i Q$		ρ, ohm-cm	T_c, F	Frequency Range, mc	λ at B_s, μ in./in.
							0.1 Mc	1.0 Mc				
CR-4	590	1800	3050	1170	0.5	+0.4	—	—	150	400	0.01-2	—
CR-20	150	740	3000	2040	2.5	±0.06	64×10^{-6}	78×10^{-6}	9×10^{-6}	475	0.01-5	−5.7 to −7.0
CR-70	895	2400	4200	1840	0.67	Stable to 300 F	1.68×10^{-4}	—	50	410	0.01-2	—
CR-71	560	2950	3650	1850	0.3	+0.41	—	1.75×10^{-4}	50	400	0.01-2	—
CR-80	1250 (1 kc)	3250	3600	920	0.16	+0.36	—	—	2×10^3	390	0.01-2	−2.2
BX-113	75 (1 kc)	250	2400	1500	5.0	+0.11	—	—	5×10^7	480+	5-80	—
BX-114	20 (1 kc)	125	1800	800	8.5	+0.11	—	—	2.5×10^6	480+	40-200	—

ALLEN-BRADLEY CO.[a]

Grade →	WO-1		WO-3		WO-4		R-02
Temp, F →	77	240	77	240	77	240	77
μ_i (16 kc), g/oe	850	—	2000	—	800	—	395
μ_{max} (16 kc), 10^3 g/oe	5 (20)	6 (30)	6 (30)	6 (30)	4.7 (30)	6 (30)	810[b]
B_{max} (16 kc; 6 AT/cm), 10^3g	2.85 (10)	2 (10)	4.2 (8)	2.8 (10)	4.6 (8)	3.7 (10)	3.03[b]
Core Loss							
B = 1350 Gauss							
16 Kc	5.8[c]	4.4[c]	4.1 (20)	4.2 (20)	5.5 (20)	4.1 (20)	—
60 Kc	9.5[c]	7.9[c]	5.5 (20)	6.5 (20)	6.5 (20)	5.5 (20)	—
B = 1800 Gauss							
16 Kc	9.2[c]	7.4[c]	6.9 (20)	6.9 (20)	9.0 (20)	6.9 (20)	—
60 Kc	16.0	14.5[c]	9.1 (20)	10.0 (20)	10.5 (20)	9.1 (20)	—
B_u, 10^3 g	1.2 (20)	—	2.1 (15)	—	3.2 (15)	—	—
μ at B_u, 10^3 g/oe	5 (25)	—	5.6 (25)	—	3.3 (25)	—	—
Q (2 mc)	—	—	—	—	—	—	57
Temp Coef of μ_i (77-212 F), %/°F	—	—	—	—	—	—	0.031
T_c, F	356	356	356	356	500	500	—
ρ_{dc}, ohm-cm	—	—	—	—	—	—	1.7×10^6
Applications	For medium frequencies where high flux density is desired, e.g., flyback transformers and deflection yokes						For high frequency saturable reactors, broad band transformers, permeability tuners and antennas where extreme temperature stability and low losses are desired

[a]Values given in parentheses are ± tolerances expressed as percentages.
[b]At 4 kc. [c]Tolerances on values are +30, −20%.

continued ↓

continued

Properties of Typical

THERMO MATERIALS, INC.

Grade ↓	Frequency Range, cps	μ_i, g/oe	μ_{max}, g/oe	B_s,g	B_r,g	H_c,oe	Q	Temp Coef of μ_i (32-175 F), %/°F	T_c, F
NT3	200 kc-1 mc	310	580	2900	1500	1.1	50[a], 35[b]	+0.11	345
NT4	200 kc-1.5 mc	275	3100	3800	2700	0.6	40[a], 32[b]	+0.22	615
NT7	5-20 mc	35	120	2100	1400	6.3	135[c], 55[d]	+0.11	995
NT8	10-300 kc	22	60	2100	1500	14	170,[d] 50[e]	+0.19	1095
PT1	10-300 kc	1050	1800	3500	1000	0.35	85[f],100[f]	+0.11	300
PT2	10-100 kc	1200	3000	4000	1300	0.23	27[g], 23[f]	+0.28	330
PT3	10-300 kc	520	1300	2800	1800	0.7	50[f], 38[h]	+0.33	255
PT4	1-50 kc	2000	3000	3300	1250	0.2	—	+0.44	265

[a]At 500 kc. [b]At 1 mc. [c]At 5 mc. [d]At 20 mc. [e]At 50 mc. [f]At 100 kc. [g]At 50 kc. [h]At 300 kc.

Grade ↓	μ_i, g/oe	μ_{max}, g/oe	B_s (9 oe), g	B_r, g
5N	480	1530	2500	1250
7A	780	4700	2800	2150
9	190	490	3000[a]	1980
20	1835	5550	3950	1550
23	1200	4000	3400	1750
23B	420	1880	3950	2200
27	920	2390	4200	1925

[a]At 18 oersteds.

LIGNES TELEGRAPHIQUE ET TELEPHONIQUE

Grade ↓	μ_i (0.8 kc), g/oe	B_s, g	H_c, oe	B_{10}, g 68 F	B_{10}, g 212 F	Temp Coef of μ_i, %/°F	Q	μQ (x 10^4)	ρ, ohm-cm	T_c, F	Recommended Uses
FERMALITE											
1002	1750	4800	0.1	3800	2600	±0.03	85 (0.3 mc)	15	200	355	Below 300 kc
1003	1250	4800	0.2	3800	2600	±0.03	80 (0.5 mc)	10	400	390	200-500 kc range
1004	1750	4500	0.1	3500	2400	+0.11, −0.03	50 (0.2 mc)	10	200	320	Below 300 kc
1005	1000	3400	0.5	2700	1800	—	100 (0.2 mc)	10	—	285	Below 500 kc
2002	2400	4500	0.1	3500	2400	±0.06	40 (0.2 mc)	10	50	340	Bobbins
2003	4000	4500	0.1	3500	2400	+0.11	—	—	25	340	Transformers
3001	1800	5300	0.2	4300	3500	—	—	—	50	465	TV transformers
3002	800	5300	0.2	4300	3500	—	—	—	50	465	TV transformers
FERNILITE											
1101	800	3500	0.3	—	—	+0.8	25 (0.5 mc)	2	$>10^5$	212	0.2-2 mc range
1102	250	4200	1.3	—	—	+0.2	40 (2.5 mc)	1	$>10^5$	570	1-7 mc range
1103	100	3900	4.0	—	—	+0.11	50 (7.5 mc)	0.5	$>10^5$	715	5-15 mc range
1104	30	3500	6.0	—	—	+0.06	110 (30 mc)	0.33	$>10^5$	895	10-60 mc range
1105	15	2500	15.0	—	—	+0.03	130 (75 mc)	0.2	$>10^5$	1075	50-120 mc range
2101	3000	3500	0.2	—	—	—	—	—	2000	175	0-1 mc range

Glossary of Symbols[a]

B—flux density or induction.
B_{max}—maximum flux density.[b]
B_r—remanent flux density.
B_s—saturation flux density.[b]
B_u—usable flux density, i.e., density at which the 240 F initial permeability is half the 77 F value.
f—frequency, cps.
g—gauss.
H—magnetizing force or drive.
H_c—coercive force.
λ—magnetorestriction.
μ_i—initial permeability.
μ_{max}—maximum permeability.
oe—oersteds.
Q—quality rating applied to coil or resonant circuits; determined by formula:

$$Q = \frac{\text{frequency x inductance}}{\text{resistance}} \times 2\pi$$

ρ—resistivity.
T_c—Curie temperature.

[a] Although many of these terms are not standardized, the ones shown here are used in this article.
[b] Saturation flux density is the theoretically highest flux density value, i.e., when H is at a value where the core material has no effect; maximum flux density is the maximum density for any specified level of magnetizing force.

of the materials (about 5000 g) is still considerably lower than that of metals (over 15,000 g), limiting the use of such ferrites to high frequencies where metals are not applicable.

Table 3 lists typical applications for soft ferrites and the properties of particular concern to the engineer or designer. Commercially available ferrites have certain limitations of which producers are generally aware. Thus to minimize rejection rate and cost, the engineer should allow maximum tolerances, both in electrical characteristics and dimensions.

Commercial Soft Ferrites

STACKPOLE CARBON CO. (Ceramag)

H_c, oe	Temp Coef of μ_i, %/°F	Merit factor ($\mu_i Q$) 15 Kc	Merit factor ($\mu_i Q$) 1 Mc	Loss (1000 g; 2 kc), w/kg	ρ, ohm-cm D.C.	ρ, ohm-cm 15 Kc	ρ, ohm-cm 500 Kc	Freq Dependance, μ_i at 0.2 oe 4 Kc	Freq Dependance, μ_i at 0.2 oe 100 Kc	Freq Dependance, μ_i at 0.2 oe 500 Kc	T_c, F	Applications
0.55	+0.055	9×10^4	4×10^3	2.88	1.2×10^3	1.98×10^3	2.35×10^2	555	520	490	390	Coil forms, cap cores, thread cores, etc.
0.35	+0.715	5.5×10^4	4×10^3	1.42	5×10^3	2.55×10^3	—	2925	1650	1025	345	Yoke cores
2.0	+0.12	6.3×10^4	3.8×10^4	8.5	1×10^{11}	—	—	—	—	—	410	Direction finder antenna plates
0.19	+0.27	3.1×10^5	1.5×10^3	0.72	2.3×10^4	—	—	5000	3525	2050	340	Flyback transformers
0.33	+0.17	3.9×10^5	—	0.9	5×10^3	—	—	2625	2100	1725	320	Pulse transformers
0.72	+0.15	1.6×10^5	1.17×10^4	3.1	2.7×10^2	—	—	555	530	510	610	—
0.5	+0.083	4.8×10^5	1.4×10^4	1.1	2.2×10^3	—	—	1150	1150	1150	435	Higher $\mu_i Q$ and μ_i than 5N grade

GENERAL ELECTRIC CO. (Type MB Ferrite)

μ_i (1 mc; 10 oe), g/oe	1550
Q	1.7
D.C. Data (10 oe)	
B_s, g	4200
B_r, g	1700
μ_{max}, g/oe	4400
Data at 15 KC (10 oe)	
B_s, g	4200
B_r, g	1700
H_c, oe	0.42
Hysteresis Loss (2000 g) w/cu cm	0.199
Temp Response of B with H, 1000 g	
0.3 Oersted	
77 F	0.90
212 F	0.90
300 F	1.00
0.6 Oersted	
77 F	2.07
212 F	1.89
300 F	1.47
0.9 Oersted	
77 F	2.53
212 F	2.14
300 F	1.75
T_c, F	445

NOTE: Lack of standardization makes tabulation of data according to generic types of ferrites impractical. These data were collected by the author from producing companies and are typical for materials now commercially available. The types of data presented by various producers show that there is still considerable disagreement as to what constitutes basic data. In order to help solve this problem ASTM Committee C-21 and other organizations are in the process of establishing test specifications for these properties.

FERROXCUBE CORP. OF AMERICA[a] (Ferroxcube)

Grade ↓	μ_i, g/oe[b]	μ_{max}, g/oe	B_{max}, g At 10 Oe 68 F	B_{max}, g At 10 Oe 212 F	B_{max}, g At 2000 Oe, 68 F	Temp Factor (68-122 F), $d\mu/\mu_i^2 dT_c$	ρ_{dc}, ohm-cm	T_c, F
3A	1400 (15)	—	3000	1000	3250	4.5×10^{-6}	20	212
3B	900 (20)	—	3400	2300	4500	3×10^{-6}	20	300
3B2	900 (20)	—	3400	2300	4500	2×10^{-6}	80	300
3B3	900 (20)	—	3400	2300	4500	2×10^{-6}	120	300
3B4	900 (20)	—	3400	2300	4500	4×10^{-6}	20	300
3B5	1200 (20)	—	3400	2300	4500	4×10^{-6}	20	300
3C2	1100 (20)	2000	3300	2200	4650	4.5×10^{-6}	80	300
3D2	750 (20)	1600	3600	2800	5100	4.5×10^{-6}	80	410
3E	2500 (15)	—	3600	—	4000	4×10^{-6}	300	212
4A	600 (20)	—	2900	1800	3600	6×10^{-6}	10^5	255
4B	250 (20)	750	3300	2700	4200	8×10^{-6}	10^5	480
4C	125 (20)	—	2800	2500	4100	12×10^{-6}	10^5	660
4D	50 (20)	—	2500	2300	3650	15×10^{-6}	10^5	750
4E	15 (20)	—	1900	1800	2300	15×10^{-6}	10^5	930

[a]American representative for Philips, Eindhoven, Netherlands; British representative is Mullard-Ltd. which has comparable grades.
[b]Values in parentheses are ± tolerances, expressed as percentages.

D. M. STEWARD MFG. CO.

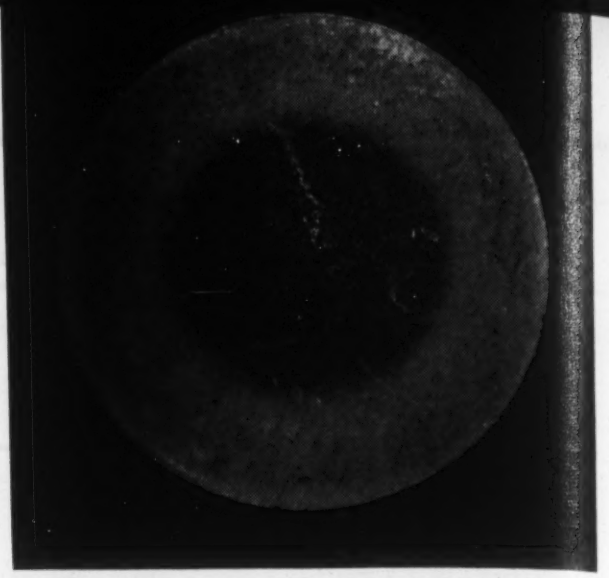
Grade ↓	μ_i, g/oe	μ_{max}, g/oe	B_s, g	B_r, g	H_c, oe	ρ, ohm-cm	T_c, F	Comments, Uses
F-4S[a]	500	2000	2700	1000	0.35	10^7	300	Useful to 5 mc for μ_i, 500 kc for Q
F-4S-1	800	4000	3400	1500	0.20	10^4	300	High μ_i to 0.5 mc
F-112	1000	1800	3400	700	0.25	10^2	265	High Q to 500 kc; high μ_i and Q up to 250 kc
F-7B	300	750	2900	1600	0.80	10^7	390	Useful up to 10 mc
F-200[b]	145	450	3000	1400	2.00	10^7	570	Useful up to 15 mc

[a]Deflection yoke body. [b]Antenna rod body.

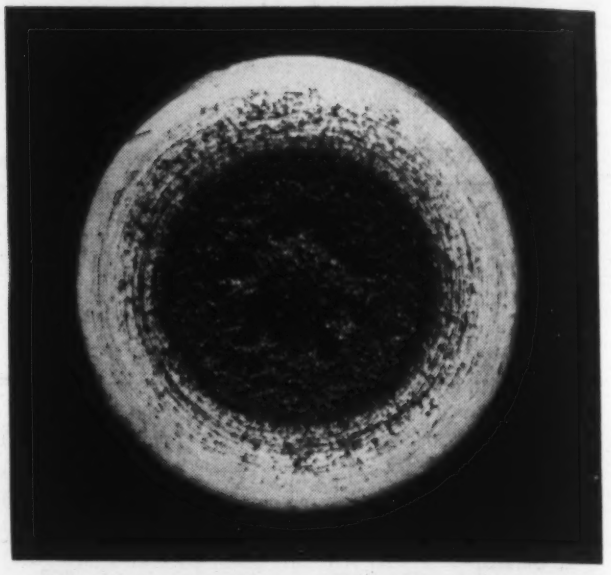
Tables in the accompanying box list typical properties of proprietary grades of soft ferrites supplied by various manufacturers. It is clear from the data that there is a substantial difference in the specific properties each producer feels is most important, emphasizing the need for standardization in method of reporting characteristics of the materials, as well as in methods of testing.

References and acknowledgments will be given at the end of Part 2 of this article next month.

Fig 1 →



Good—*Cast aluminum bronze has excellent resistance to cavitation erosion.*



Poor—*By comparison, cast steel deteriorates badly under cavitation conditions.*

Selecting Materials to

Avoid Cavitation Damage

The repeated formation and collapse of bubbles that may result from local pressure conditions can produce rapid and severe erosion in hydraulic equipment. The author tells how to minimize or eliminate such damage through proper selection of materials.

by William J. Rheingans, *Manager, Hydraulic Dept., Allis-Chalmers Mfg. Co.*

TABLE 1—HOW METALS RATE IN RESISTANCE TO CAVITATION EROSION
(Typical Hydraulic Equipment Materials)

Alloy	Weight Loss After 2 Hr, mg
Rolled Stellite[a]	0.6
Welded Aluminum Bronze[b]	3.2
Cast Aluminum Bronze[c]	5.8
Welded Stainless Steel (2 layers, 17 Cr-7% Ni)	6.0
Hot Rolled Stainless Steel (26 Cr-13% Ni)	8.0
Tempered, Rolled Stainless Steel (12% Cr)	9.0
Cast Stainless Steel (18 Cr-8% Ni)	13.0
Cast Stainless Steel (12% Cr)	20.0
Cast Manganese Bronze	80.0
Welded Mild Steel	97.0
Plate Steel	98.0
Cast Steel	105.0
Aluminum	124.0
Brass	156.0
Cast Iron	224.0

GOOD ↑ ↓ POOR

[a]Despite the high resistance of this material to cavitation damage it is not suitable for ordinary use because of its comparatively high cost and the difficulty encountered in machining and grinding.
[b]Ampco-Trode 200: 83 Cu-10.3 Al-5.8% Fe.
[c]Ampco 20: 83.1 Cu-12.4 Al-4.1% Fe.

■ It is quite difficult to predict the resistance of a material to cavitation damage on the basis of the material's physical and mechanical properties. Aside from actual field testing which is often impractical, resistance to cavitation erosion can best be determined by accelerated laboratory tests (see box for explanation). Such tests show an extremely wide variation—on the order of 300 to 1—in the resistance of various materials to damage.

As indicated in Table 1, various types of stainless steel and aluminum bronze provide the best resistance to cavitation erosion in hydraulic equipment. There is a wide variation in the resistance of similar materials, and a small change in a material's chemical content or properties can substantially affect its resistance to cavitation damage.

Stainless steels

The various stainless steels show a considerable difference in their resistance to cavitation erosion. Even specimens of supposedly similar steels can produce different results. Nevertheless, with few exceptions, the stainless steels are generally quite good in resisting cavitation damage. Their high resistance generally stems from their: 1) tough, homogeneous, fine crystalline structure, 2) high corrosion fatigue limit, 3) high tensile strength, 4) ability to be hardened to a high degree by heat treatment, and 5) tendency to work-harden under repeated blows.

Table 2 shows the weight loss of single and double layers of stainless steel welds over cast steel. Note that the hardness of these materials is a good measure of their resistance to damage.

Resistance of Various Materials to Cavitation Erosion

TABLE 2—WELDED STAINLESS STEEL LAYERS[a]

Alloy, %		Brinell Hardness	Weight Loss After 2 Hr, mg
1st Layer	2nd Layer		
17 Cr-7 Ni	None	308	10
18 Cr-8 Ni	None	160	23
25 Cr-12 Ni	None	145	26
17 Cr-7 Ni	17 Cr-7 Ni	255	6
18 Cr-8 Ni	17 Cr-7 Ni	167	14
18 Cr-8 Ni	18 Cr-8 Ni	166	19
17 Cr-7 Ni	18 Cr-8 Ni	101	19
25 Cr-7 Ni	18 Cr-8 Ni	101	19

[a]Over cast steel.

TABLE 3—ROLLED AND CAST STAINLESS ALLOYS

Alloy, %	Condition	Brinell Hardness	Weight Loss After 2 Hr, mg
ROLLED			
26 Cr-13 Ni	Hot Rolled	161	8
12 Cr-0.16 Ni	Tempered	401	9
12 Cr-0.16 Ni-0.35 Mo	Hot Rolled	375	9
12 Cr-1 Ni-0.49 Mo	Tempered	341	14
24 Cr-12 Ni	Annealed	139	17
12 Cr	Tempered	213	40
12 Cr-1 Ni-0.49 Mo	Annealed	200	66
12 Cr-0.16 Ni-0.35 Mo	Annealed	156	85
12 Cr	Annealed	142	93
CAST			
18 Cr-8 Ni			13
18 Cr-9 Ni		146	22
18 Cr-8 Ni			33
12 Cr		302	20
14 Cr		269	34
13 Cr		223	47

TABLE 4—ALUMINUM BRONZES

Alloy, %	Form	Brinell Hardness	Weight Loss After 2 Hr, mg
83 Cu-10.3 Al-5.8 Fe[a]	Welded	220	3.2
85 Cu-9.3 Al-4.8 Fe[b]	Welded	185	5.9
89 Cu-10 Al-1 Fe[c]	Welded	140	24.0
83.1 Cu-12.4 Al-4.1 Fe[d]	Cast	235	5.8
81.7 Cu-13.4 Al-4.4 Fe[e]	Cast	340	9.5
84.6 Cu-11.3 Al-3.7 Fe[f]	Cast	170	12.0
84.6 Cu-11.3 Al-3.7 Fe[f]	Rolled	190	12.0

[a]Ampco-Trode 200. [b]Ampco-Trode 160. [c]Ampco-Trode 10. [d]Ampco 20. [e]Ampco 22. [f]Ampco 18.

TABLE 5—VARIOUS WELDING ALLOYS

Alloy	Brinell Hardness	Weight Loss After 2 Hr, mg
Lincoln Abrasoweld[a]	320	2.5
Arcos Chromend[b]	275	8.5
Smithway[c]	137	23
Lincoln A5		27
Lincoln Standard 0[d]	145	27
Victor W2310	136	29
Arcos Chromend K[e]	130	38
Lincoln Aerisweld AE-124 K		55
Monel 140-X	146	89

[a]12% Cr alloy steel. Despite the high resistance of this material to cavitation damage its use is limited because of the difficulty encountered in grinding and machining. [b]18 Cr-7% Ni. [c]18 Cr-8% Ni. [d]25 Cr-20% Ni. [e]19 Cr-9% Ni.

TABLE 6—SPRAYED METAL COATINGS

Alloy	Weight Loss After 2 Hr, mg
UNFUSED	
High Chromium Stainless Steel[a]	72
18 Cr–8% Ni Stainless Steel[b]	98
13% Cr Stainless Steel	192
Molybdenum	358
FUSED	
65 to 75 Ni–15 to 20 Cr–2.7 to 4.7% B[c]	8
75 to 85 Ni–8 to 14 Cr–2 to 3% B[d]	30

[a]Metcoloy 2. [b]Metcoloy 1. [c]Colmonoy 6. [d]Colmonoy 4.

TABLE 7—NONMETALLIC COATINGS

Coating	Volume Loss After 2 Hr, cu mm	Weight Loss After 2 Hr, mg
Nylon	7	8
Phenolic Resin on Fabric Base	20	26
Rubber Flame Sprayed on Mild Steel	29	33

This relationship is not always valid but for these particular materials it holds true.

The difference between the resistance of one and two welded layers is largely due to dilution of the base metal. The highest resistance is apparently obtained when the outermost layer contains 16-17% chromium and 5-7% nickel. The high resistance to cavitation damage of a stainless steel welded layer is shown by the photo in the box on p 105. The base metal of cast steel shows considerable cavitation erosion after two years of operation, whereas the stainless steel (18 chromium-8% nickel) weld at the bottom is not damaged and still retains original grinding marks.

Cavitation Explained

What is cavitation?

Cavitation can be defined quite simply as the formation and collapse of cavities and bubbles within a liquid. The bubbles are produced at points in a liquid where the local pressure becomes equal to, or falls below, the vapor pressure of the liquid. These cavities and bubbles (which are filled with a cold vapor) start to collapse as they are carried along to a region of higher pressure. It is this collapsing action that causes cavitation damage.

A simple means of demonstrating cavitation is offered by the venturi in the accompanying sketch. At low velocities and high pressures the water follows the diverging walls of the venturi after leaving the throat. However, as the velocity is increased or the pressure is decreased in the throat, a condition occurs whereby the water can no longer adhere to the diverging walls. A cavity forms and the water starts to vaporize and form bubbles. As these cavities and bubbles reach an area of higher pressure they collapse and cause damage. The bubbles are not usually visible because they form and collapse very rapidly. However, a hissing noise is produced by their collapse.

Effects of cavitation

Cavitation can affect performance by:

Producing vibration and noise—The collapse of cavities and bubbles during cavitation can produce severe vibration and noise in hydraulic structures and machinery. These conditions can become severe enough to damage the structure or make operation impossible. A good example is the vibration and noise produced by the water flowing at high velocity through a partly opened gate valve.

Lowering efficiency—Under certain conditions the formation of large cavities can reduce the efficiency and output of hydraulic machinery such as pumps and turbines. In this case cavitation alters the size of water passages and prevents normal flow. Also, cavitation on a ship propeller can reduce thrust efficiency and cause a drop in speed. Cavitation on fins and rudders can reduce their stabilizing effect and cause a loss of control.

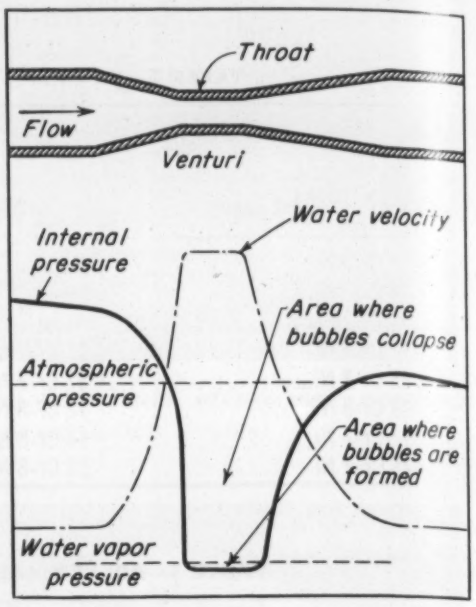
Eroding materials—This is the most serious and common type of cavitation damage. It is usually referred to as pitting and, as shown in the accompanying photo, is characterized by deep pits, depressions and pock marks. Pitting is readily distinguished from rusting or chemical corrosion, and from erosion caused by sand, silt or other foreign materials. In addition to metals, such materials as glass, rubber, plastics, wood and concrete are all subject to cavitation damage.

How damage is produced

It is now fairly well accepted that pitting or cavitation erosion is caused by a mechanical action which in some cases may be accompanied by chemical corrosion. The theory of mechanical erosion is supported by the fact that chemically inert materials exhibit the same type of attack as metals.

High speed motion picture photographs show that cavitation bubbles can grow to a size of ¼ in. in only 0.002 sec, and completely collapse in 0.001 sec. Calculations indicate that the rapid collapse of bubbles can produce pinpoint pressures of 30,000 to 50,000 psi.

Pressures of this magnitude are not high enough to cause immediate erosion of most materials. However, photographs have shown that with certain types of cavitation nearly 2 million bubbles can form and collapse in 1 sec in an area 1 in. in dia. Thus, with repeated blows at 30,000 to 50,000 psi, the material will fail by fatigue. In addition to causing fatigue failure, the high stress concentrations can break down the crystalline structure of the material.



Cavitation *conditions occur when internal pressure drops below water vapor pressure.*

Erosion *caused by cavitation is characterized by deep pits, depression and pock marks.*

Tests with soft aluminum show that only about one bubble in 30,000 actually produces a pit or indentation. Once pitting starts, the rate of damage increases as the sixth power of the relative velocity between the fluid and the boundary surface. After a few minutes, indentations varying from 0.0025 to 0.010 in. in dia are formed. No metal removal takes place during the early stages of cavitation, indicating that the metal is being deformed by mechanical blows. However, actual metal removal begins to occur after continued exposure to cavitation.

Table 3 shows the resistance of both rolled and cast stainless steels to cavitation erosion. It is quite evident that the type of heat treatment has a considerable effect on resistance. As with the welded grades, hardness has an influence on resistance. As the data shows, however, hardness is not the controlling factor.

Aluminum bronzes

In addition to the stainless steels described above, the aluminum bronzes also show consistently good resistance to cavitation erosion under both actual operating conditions and accelerated laboratory tests. As in the

In general, all structures and machinery dealing with moving liquids are subject to cavitation and cavitation damage. Cavitation damage is commonly encountered in hydraulic machinery, particularly in turbines and centrifugal pumps. It also occurs in the water jackets of diesel engine cylinders. Cavitation occurring over a spillway or through a dam outlet can remove many yards of concrete in an incredibly short time. Needle valves, spillway gates and valve seats can all be damaged by cavitation. Even concrete piers located in flowing water are subject to damage.

How materials are evaluated

In theory, actual field testing is the best way to evaluate the resistance of materials to cavitation damage. However, because of the time, expense and close control required, this type of testing has not proved very feasible. For this reason various laboratory methods have been developed for producing accelerated cavitation damage.

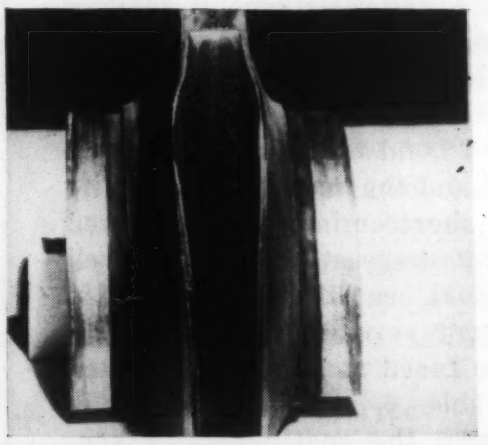
One of the most popular methods consists of a vacuum tube oscillator which produces an alternating magnetic field in a nickel tube, at the end of which is attached the test specimen immersed in distilled water. When the frequency of the magnetic field is the same as the natural longitudinal frequency of vibration of the nickel tube, the tube and the specimen vibrate at maximum amplitude in a longitudinal direction.

Cavitation damage is produced because the frequency of vibration of the test specimen is so high that the liquid cannot follow the rapid movement of the specimen. The pressure differential created produces a cavity on the bottom surface of the specimen which is accompanied by the formation and collapse of bubbles during each cycle of vibration. The collapse of the bubbles produces cavitation erosion. The rate of erosion is measured by the weight loss of the specimen in milligrams after 2 hr of testing.

Here is what cavitation did to . . .

Cast steel

Cast iron



Bronze

case of the stainless steels, the high resistance of these materials derives from their: 1) tough, homogeneous structure, 2) high corrosion fatigue limit, 3) high tensile strength, and 4) good hardness.

As shown in Table 4, the weight loss of these materials after accelerated cavitation testing is quite low. The excellent resistance of these materials to erosion is also shown in Fig 1, which shows the markedly better resistance of cast and welded aluminum bronzes as compared to cast steel and cast stainless steel.

Welded layers

The most common and economical materials for hydraulic equipment are cast iron, cast bronze, cast steel and plate steel. These materials have comparatively low resistance to cavitation erosion. Because of this they must usually be repaired or coated with a material that is more highly resistant to erosion.

As indicated previously, welded

***Fig 2**—Stainless steel welded layers are used at critical areas where cavitation damage is likely to occur.*

continued

layers of stainless steel or aluminum bronze are ideally suited for protection. In addition, many other types of welding materials are available for protecting base metals. Some of these materials are listed in Table 5. In addition to being used for repair purposes, these materials are often overlayed over areas where damage is expected to occur. This is illustrated in Fig 2 which shows an 18 chromium-8% nickel layer placed on the bottom of a Kaplan blade.

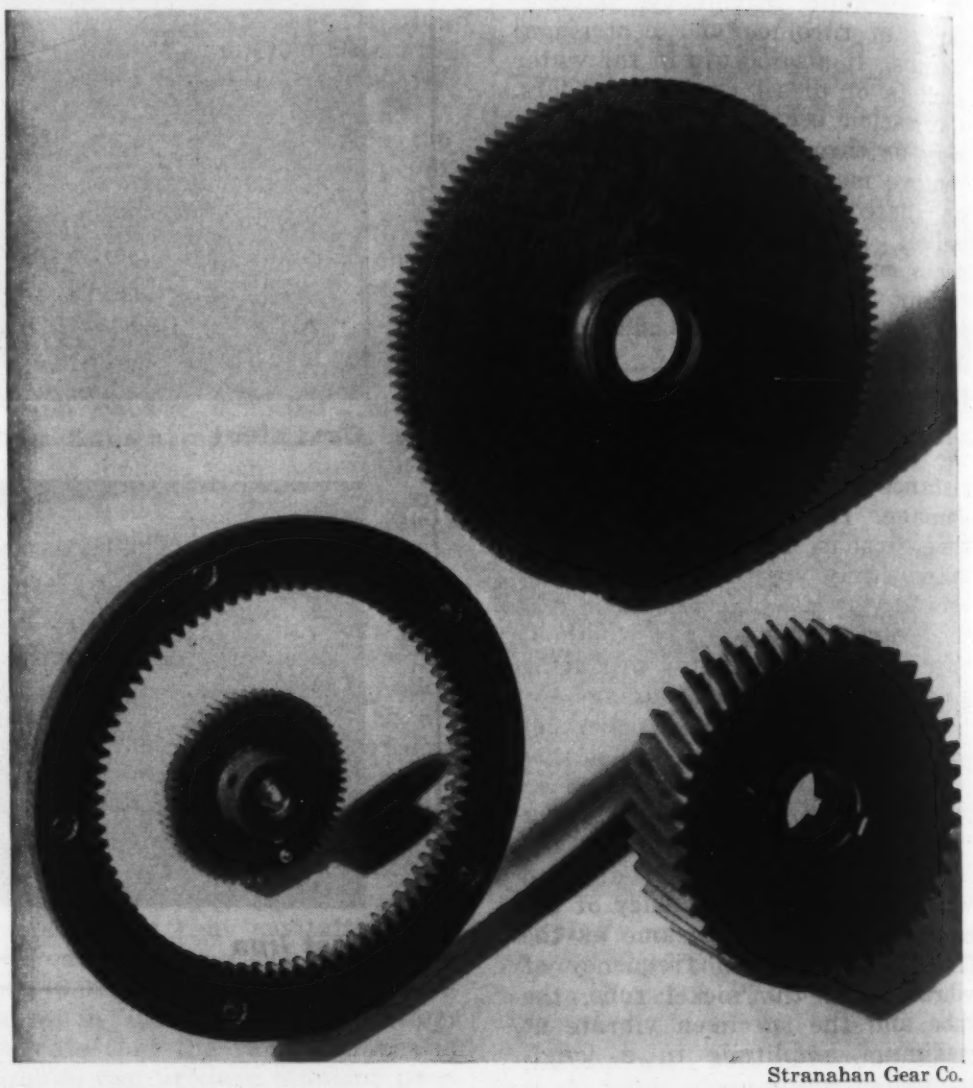
Sprayed coatings

Much work has been done with sprayed metals for repairing damaged metals. As shown in Table 6, the resistance of unfused coatings to accelerated cavitation testing is not very good. In some cases it is also difficult to produce a good bond between the sprayed metal and the base metal. Despite these shortcomings, some sprayed coatings have stood up quite well in actual use where cavitation is not very severe.

The fused metal coatings listed in Table 6 were prepared by spraying the coatings on a specially prepared base and then heating at 1850 F. Although these coatings have good resistance to erosion, they are limited by their high cost and by the distortion produced in the base metal during fusion.

Various nonmetallic coatings such as rubber, plastics and ceramics have also been tried for protecting base metals. However, major difficulties have been encountered because of poor bonding. The cavitation action is so severe in many cases that it tears the coatings away from the base metal. Ceramic coatings, for example, have so little resistance to cavitation damage that they lose from 5 to 120 mg after only 1 min of testing.

The damage produced in three typical nonmetallic coatings after accelerated testing is shown in Table 7. Note that the critical criterion when testing these lighter materials is their volumetric (not weight) loss.



Stranahan Gear Co.

These are . . .

Laminated Plastic Gears for | *Silent Operation* *High Horsepower*

Of the silent gear materials, industrial thermosetting laminates provide the highest horsepower ratings. Here are the properties of gear laminates and the formulas needed to design the most effective silent gears.

by George J. Muller, *Taylor Fibre Co.*

■ Industrial thermosetting laminate gears, either molded or machined from sheet stock, are widely used as one of a series of mating gears to reduce gear train noise and vibration. They are most effective in high speed applications, involving pitchline velocities of over 600 fpm; at lower velocities, careful consideration must be given to starting torque or the possibilities of high shock loading.

Advantages

Laminated plastics have a high degree of elastic deformability or resilience and a low modulus of elasticity. Thus, in addition to silent operation, laminated plastics gears offer the following benefits:

1. High resistance to abrasive wear and impact loading. In many cases, plastics gears outwear certain types of metal gears. Maximum gear durability is obtained by mating such gears with gears of hardened steel or cast iron.

2. Dimensional tolerances are not as critical as with more rigid materials, since higher resilience permits the absorption of small errors in tooth design.

3. Safety factor. Under overload conditions in a gear train, the plastics gear, since it is not as strong as the metal ones, breaks first, preventing damage to metal gears, shafts or other components. Laminated gears are relatively easy to replace and in many cases are less expensive than metal gears.

Which laminated plastic?

Of the industrial thermosetting laminates, cloth-base grades are most commonly used for high horsepower applications; paper-base laminates are usually used for small gears where horsepower is not critical. Of the cloth-base grades, NEMA (National Electrical Manufacturers' Assn.) Grade C, a canvas-base phenolic laminate, is most used. The reinforcement in this grade is the coarsest fabric used in any of the cloth-base grades, and thus provides the laminate with maximum impact strength and toughness. Grade C gears are usually considered to have the power transmitting capacity of cast iron gears.

Other cloth-base laminates—CE, L, LE and MC—can provide specific benefits for particular applications. In general, the higher the machinability of a laminate, the finer and more accurate the teeth that can be produced, and the lower the noise level of operation. Grade CE has a cloth reinforcement that is somewhat finer than that of Grade C; Grade L is a fine weave, cotton linen-base phenolic laminate with further improved machinability; and Grade LE is an even finer grade. Usually, as machinability improves, toughness and impact strength suffer.

Grade MC is a specialty laminate made from purified cotton fabric with a melamine resin binder. It is particularly well suited for applications such as gears in plating baths or other areas where a high degree of chemical stability is required.

Properties of all five of these grades are given in Table 1.

All grades of industrial thermosetting laminates can be produced as laminated moldings. Since the safe working stresses for sheet stock and laminated moldings (see Table 2) are about the same, the decision as to whether to specify a gear from sheet stock or as a molding is primarily dependent on production volume and the facilities of the gear supplier. In some cases, where a hub is required on the gear, molding may be more economical. In either case, gear teeth must usually be produced by subsequent machining.

How to design the gear

Horsepower ratings of gears made of laminated plastics and

TABLE 1—TYPICAL PROPERTIES OF CLOTH-BASE LAMINATES[a]

NEMA Grade →	C	CE	L	LE	MC
MECHANICAL PROPERTIES					
Tensile Strength, 1000 psi					
Lengthwise	11	11	14	13.5	11
Crosswise	9	9	10	9.5	7
Flexural Strength, 1000 psi					
Lengthwise	22	22	23	18	23
Crosswise	18	17	18	15	18
Compressive Strength (flatwise), 1000 psi	37	39	35	37	45
Modulus of Elasticity in Flexure, 10^5 psi					
Lengthwise	10	9	11	10	—
Crosswise	9	8	8	8	—
Edgewise Impact Strength, ft-lb/in.					
Lengthwise	2.3	1.6	1.3	1.3	0.9
Crosswise	2.2	1.4	1.2	1.2	0.9
Rockwell Hardness	M103	M105	M105	M105	M115
Bond Strength, lb/in.	2000	2200	1700	1800	1900
PHYSICAL PROPERTIES					
Density, gm/cu cm	1.35	1.32	1.34	1.32	1.5
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F					
Short Time	275	300	275	300	275
Continuous	225	250	225	250	225
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	0.58	0.58	0.43	0.58	—
Crosswise	0.68	0.68	0.58	0.80	—
Water Absorption (24 Hr), %					
1/16 In. Thick	4.4	1.3	2.0	1.3	2.2
1/8 In. Thick	2.5	0.9	1.4	0.8	1.6
1/2 In. Thick	1.2	0.5	0.8	0.5	1.0

[a]Properties given are average values and do not reflect NEMA limiting values.

TABLE 2—SAFE WORKING STRESS FOR CLOTH-BASE LAMINATES

Pitch Line Velocity, fpm	SWS	Pitch Line Velocity, fpm	SWS	Pitch Line Velocity, fpm	SWS
100	4500	1200	2143	2700	1810
150	4071	1300	2100	2800	1800
200	3750	1400	2063	2900	1790
250	3500	1500	2029	3000	1781
300	3300	1600	2000	3100	1772
350	3136	1700	1974	3200	1765
400	3000	1800	1950	3300	1757
450	2885	1900	1929	3400	1750
500	2786	2000	1909	3500	1743
600	2625	2100	1891	3600	1737
700	2500	2200	1875	3700	1731
800	2400	2300	1860	3800	1725
900	2318	2400	1846	3900	1720
1000	2250	2500	1833	4000	1715
1100	2192	2600	1821		

TABLE 3—VALUE OF Y
(14½ or 20 Deg Involute; Full Depth of Stub Tooth)

No. of Teeth ↓	Y		No. of Teeth ↓	Y	
	14½ Deg	20 Deg		14½ Deg	20 Deg
12	0.067	0.078	27	0.100	0.111
13	0.070	0.083	30	0.102	0.114
14	0.072	0.088	34	0.104	0.118
15	0.075	0.092	38	0.107	0.122
16	0.077	0.094	43	0.110	0.126
17	0.080	0.096	50	0.112	0.130
18	0.083	0.098	60	0.114	0.134
19	0.087	0.100	75	0.116	0.138
20	0.090	0.102	100	0.118	0.142
21	0.092	0.104	150	0.120	0.146
23	0.094	0.106	300	0.122	0.150
25	0.097	0.108	Rack	0.124	0.154

metals differ considerably because of differences in the properties of the two types of materials. Even when attempting to directly substitute a plastics gear for a metal gear, the gear should be completely redesigned, taking into consideration the properties of the plastic.

In addition to the choice of using a molding or sheet stock for the gear blank, the finished gear may be produced by a variety of machining operations. Thus, the engineer should provide the gear manufacturer with complete information on load requirements and service conditions to assist him in selecting the most efficient production method. This information should include: horsepower, torque, input and output speed, tolerances required, and the method of driving (splined or keyed), if finished i.d. is to be furnished.

For maximum strength, gears should be designed in the 20-deg stub-tooth system. In calculating the horsepower of laminated gears and pinions the standard Lewis Formula, approved by the AGMA (American Gear Manufacturers' Assn.), should be used:

$$HP = \frac{0.000095 \times SWS \times FW \times Y \times PLV}{DP}$$

where:

SWS = safe working stress of the material in psi, which varies with speed. Static stress recommended by the AGMA for nonmetallic gears is 6000 psi. Values for SWS shown in Table 2 were calculated by the formula:

$$SWS = 6000 \times \frac{150}{200 + PLV} + 0.25$$

FW = face width in in.
Y = constant depending on number of teeth; see Table 3.
PLV = pitch line velocity in fpm. This value is equal to 0.262 × rpm × pitch dia.
DP = diametral pitch.

If a keyed drive system is used, the stress in the keyway of a laminated plastics gear should not exceed 3000 psi. The following two formulas can be used to calculate this stress:
where:

$$S = \frac{33{,}000 \times HP}{VA} \qquad S = \frac{63{,}000\ HP}{rpm \times rA}$$

S = unit stress in psi.
HP = horsepower transmitted.
V = peripheral speed of shaft in fpm.
A = sq in. area of keyway in pinion (length × height).
r = shaft radius in in.

An Example of Horsepower Determination

Here is a typical application of the Lewis Formula to determine the horsepower rating of a canvas-base phenolic pinion having 21 teeth, a diametral pitch (DP) of 3, and a 4-in. face, and running at a speed of 850 rpm.

$$\text{Pitch diameter} = \frac{\text{number of teeth}}{DP} = \frac{21}{3} = 7 \text{ in.}$$

$$PLV = 0.262 \times 850 \times 7 = 1559 \text{ fpm}$$

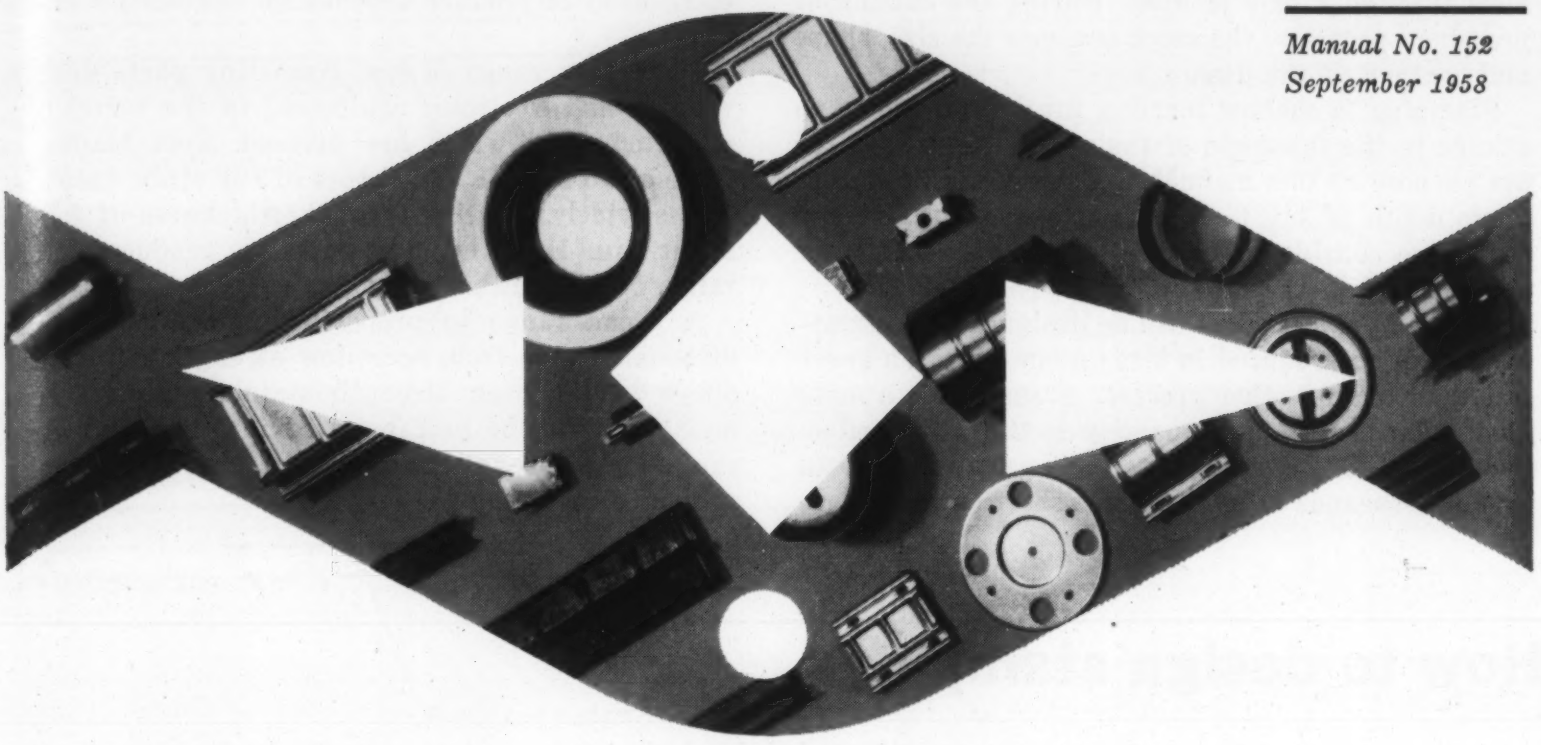
$$Y = 0.092 \text{ (for 21 teeth)}$$

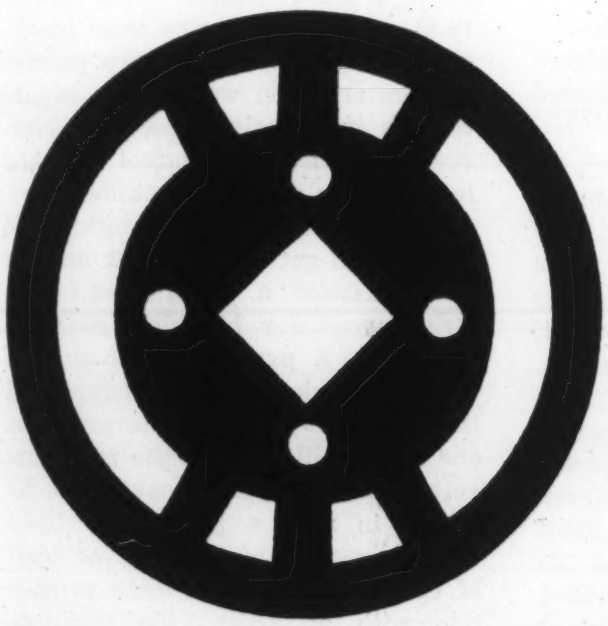
$$SWS = 6000 \times \frac{150}{200 + 1559} + 0.25 = 2012$$

$$HP = \frac{0.000095 \times 2012 \times 4 \times 0.092 \times 1559}{3} = \underline{36.55}$$

Materials
in Design Engineering

Manual No. 152
September 1958





Designing Metal Stampings

by John L. Everhart, *Technical Editor, Materials in Design Engineering*

A designer who is not fully informed on the stamping process can cost his company a lot of money—either by failing to consider stampings when he should, or by designing stampings that result in inefficient, costly production. This manual tells how to design properly for the stamping process, including such factors as blank layout, holes, bends, radii and tolerances. It also discusses the working characteristics of the metals most commonly used.

A stamping is a part of predetermined size and shape that is produced by passing cold sheet or strip steel through a pair of dies. During the cutting or pressing operation, the stock assumes the size, shape and contour of the dies.

Stamping is shallow forming involving little or no change in the thickness of the metal. As defined for the purpose of this manual, a stamping is limited to a cup depth of 1½ to 2 in. Parts with greater cup depth are considered here as drawn parts and are not included in the discussion.

Generally if a product can be designed as a stamping, it can be produced in large quantities at a lower cost than by any other process. Stamping is a mass production process and quantity is the key to effective usage. But quantity does not necessarily mean tens of thousands of pieces. Some short run stampers can produce as few as a hundred parts in competition with other processes. The minimum quantity that is economical to produce depends on the design of the part.

Stampings range in size from tiny parts used in watches and electronic equipment to the turret tops of automobiles which are pressed from blanks as large as 16 by 8 ft. Thickness of the stock used also varies widely, ranging from the thickness of foil to about 1 in. However, most parts are produced in the range between 16 and 22 gage.

A broad range in properties is available, since materials range from some low strength nonferrous alloys to the high strength stainless steels. Any metal that can be prefabricated into sheet or strip can be processed further by at least the simpler stamping operations.

How to design stampings

In any part designed as a stamping, only the designer knows which dimensions are critical. If all are critical, this should be clearly indicated; if only certain dimensions are vital to the functioning of the part, requiring close tolerances on other parts results in needless expense. The producer of stampings frequently wonders, in examining the drawings, whether the radii must be as sharp as shown, and whether all holes and slots actually require the same close tolerances. The designer should be sure that he needs everything he specifies, because each unnecessary requirement results in a needless increase in cost of the part. Consultation with a stamping producer will often lead to economies in production. Since stampings vary so widely in size, some producers specialize in small parts, others in large, and some cover a wide range of sizes. In this connection, the Pressed Metal Institute will examine a part or a drawing without charge and suggest possible producers.

All metal stamping operations can be classed as either cutting or forming. Cutting operations are those in which the metal is completely sheared by stressing beyond the ultimate strength; forming operations are those in which the metal is stressed beyond the yield point and permanently deformed.

Cutting operations

Cutting operations are designed to change the outline of the edges of a part or to cut holes in the interior. They include blanking, punching, extruding holes, piercing and lancing. The requirements of cutting operations are varied and some of the most important to be considered for effective design are discussed below.

Blanking

Blanking is the cutting of shapes out of sheet stock either to produce finished parts or as the first stage in a forming operation. The die is made to size, if size is important, and clearance is taken on the punch. If the blank is very large in relation to the metal thickness, curvature of the sheet may cause measurable inaccuracy in the blank even though the tools are accurate. Since the blank follows the shape of the punch, it is possible to form shallow shapes simultaneously with blanking; if the face of the punch has a convex contour, the metal is stretched to that shape before shearing occurs.

In blanking, the pressure required depends on the strength of the stock, and the depth of penetration before shearing occurs is inversely proportional to the hardness. Depth of penetration appears to be a measure of ductility and it has been suggested, but not definitely proved, that the percentage reduction in thickness in shearing is related to the reduction of area in the tensile test.

Since the contour and intricacy of the blank determine the cost of dies, simple blank contours should be used if possible. It may be less expensive to build up a component from several simple parts than to make it as an intricate single part. Straight-sided blanks with corner radii are less expensive than blanks with square corners. Sharp pointed corners are even worse than square corners in reducing tool life. Narrow slots also reduce tool life and increase the cost of blanking.

In blank layout, an attempt should be made to get the greatest number of blanks for a given area. Most strip layout for blanking could be improved. A practical method is to cut two blanks from cardboard and try various layouts to determine the one which will produce the minimum scrap. However, some caution is required in such a procedure. Close tolerances require cutting, at least of edges, and this prevents production with no scrap. To facilitate bending, the direction of the grain must be carefully considered. The greatest saving results if the blank can be cut from standard widths of material; sometimes a slight design change can make this possible. It is worthwhile to save a cent on each blank by better utilization of stock. At high production operations, such a saving can result in considerable reductions in cost.

Some of the factors that should be considered in designing for blanking are illustrated in Fig 1 through 4. These show a few possibilities in blank arrangement to save stock and facilitate production.

Shearing, parting and notching

These operations differ from blanking because the section being cut is

Design suggestions for blanked and punched parts

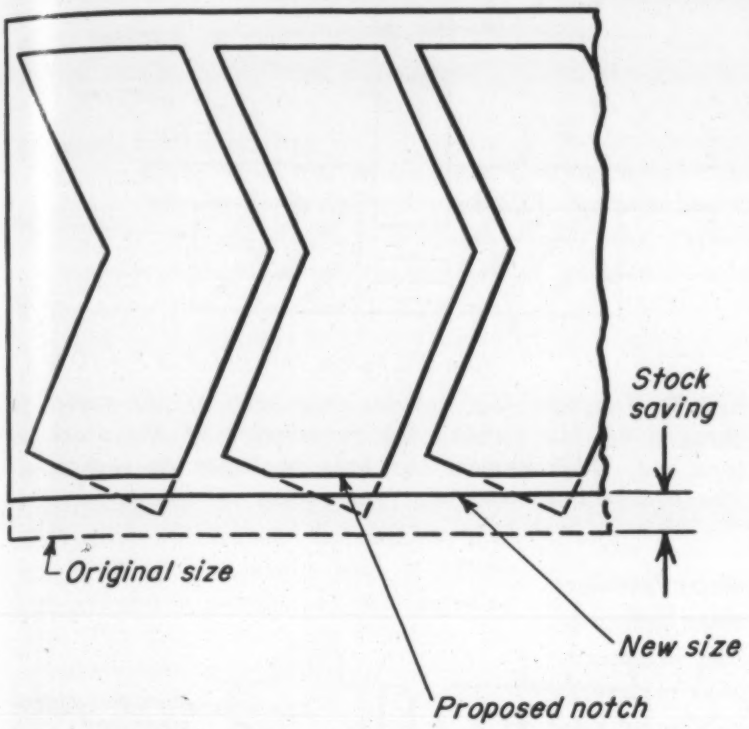


Fig 1—*Arrangement of parts for blanking must be carefully studied. Nesting or slight redesign can reduce scrap losses.* (Pressed Metal Institute)

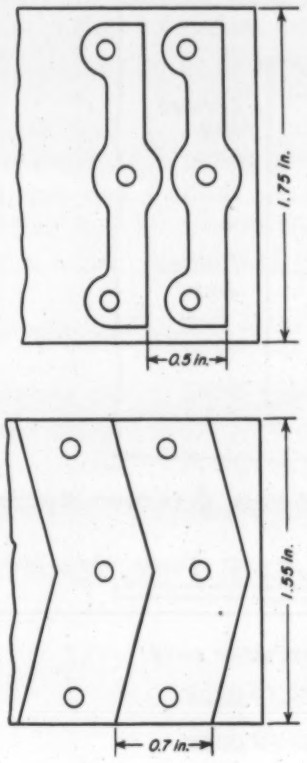
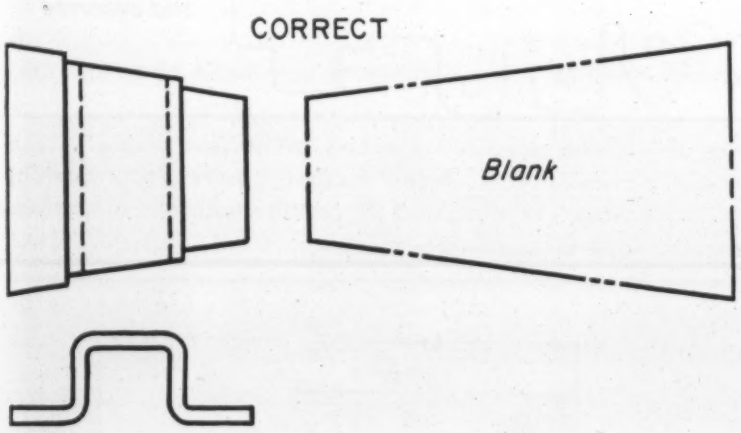


Fig 3—*Redesign can frequently reduce costs. The part below works as well as the other part but requires considerably less material.* (Strasser)



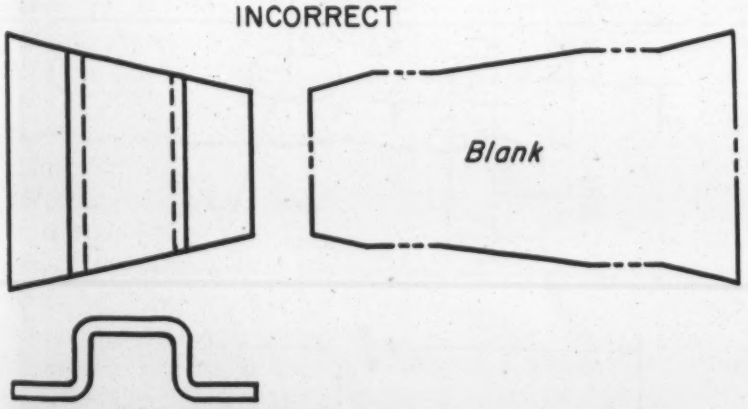


Fig 2—*For economical operation, parts should be designed to permit straight edges on flat blanks, if possible.* (Pressed Metal Institute)

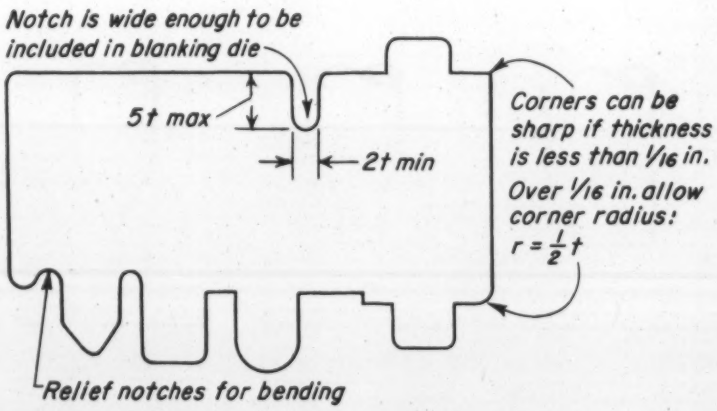

Notch is wide enough to be included in blanking die
5t max
2t min
Corners can be sharp if thickness is less than 1/16 in.
Over 1/16 in. allow corner radius:
r = 1/2 t
Relief notches for bending

Fig 4—*Attention to contour details will produce the best part at the lowest cost.* (Dayton Rogers Mfg. Co.)

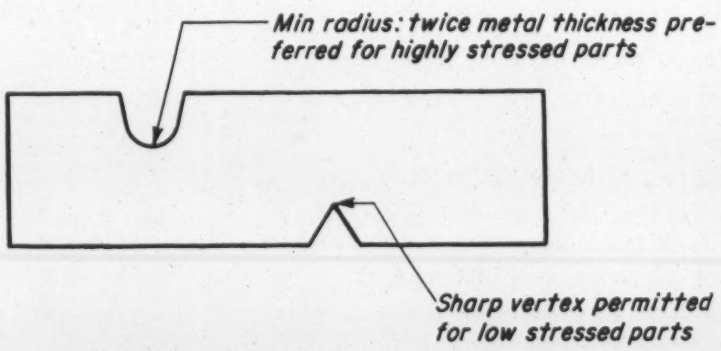


Fig 5—*Notches in highly stressed parts should be designed with the largest possible radius. Sharp notches can be used for parts not subjected to stressed conditions.* (Pressed Metal Institute)

unbalanced. Shearing is cutting along a single, usually straight, line and generally generates no additional scrap. Parting produces scrap since it involves cutting along two parallel lines. Parting has the advantage that it permits somewhat closer dimensional control than shearing.

Notching is unbalanced blanking with cutting occurring only on three sides of the punch. Because of the unbalanced forces, the part being cut tends to move away from the punch making it difficult to control

continued

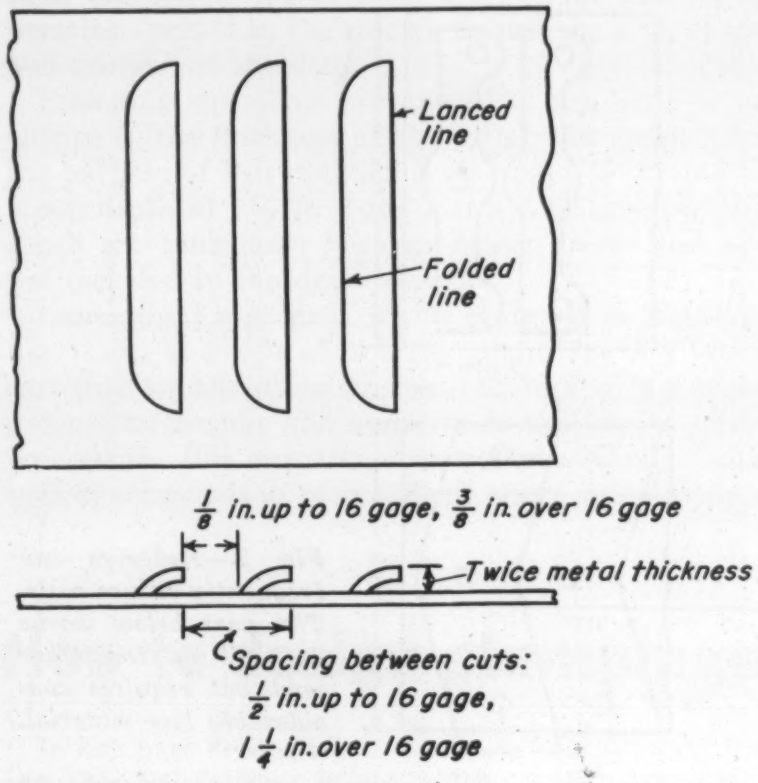

Lanced line
Folded line
1/8 in. up to 16 gage, 3/8 in. over 16 gage
Twice metal thickness
Spacing between cuts:
1/2 in. up to 16 gage,
1 1/4 in. over 16 gage

Fig 6—*Lanced areas must be designed with spacing and depths based on stock thickness.* (R. A. W.)

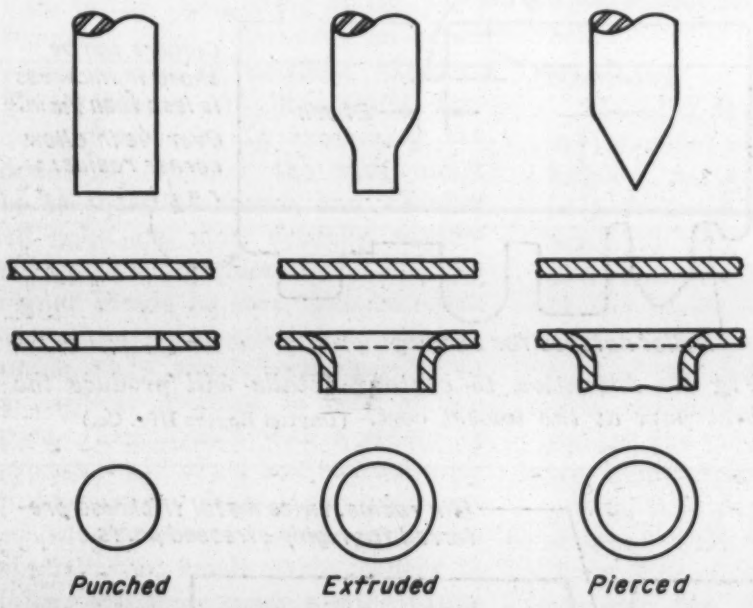


Fig 7—*Holes are punched, extruded or pierced. Punching does not increase stock thickness; extruding or piercing increases effective thickness at hole.* (Pressed Metal Institute)

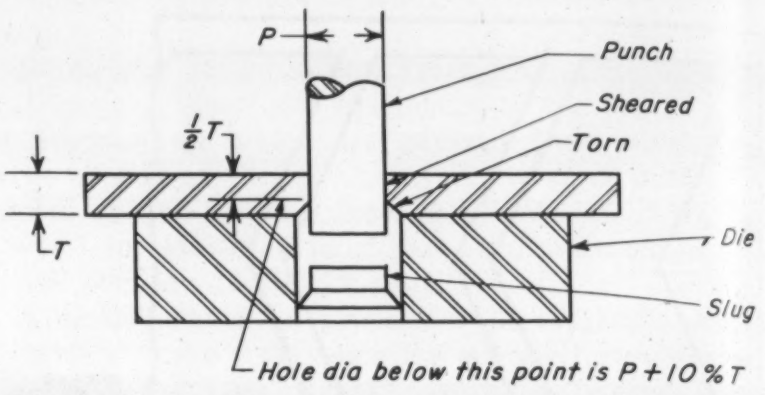


Fig 8—*In punching a hole, only part of the metal is sheared by the punch; the remainder of the stock is torn out. This causes the hole to taper as indicated.* (Pressed Metal Institute)

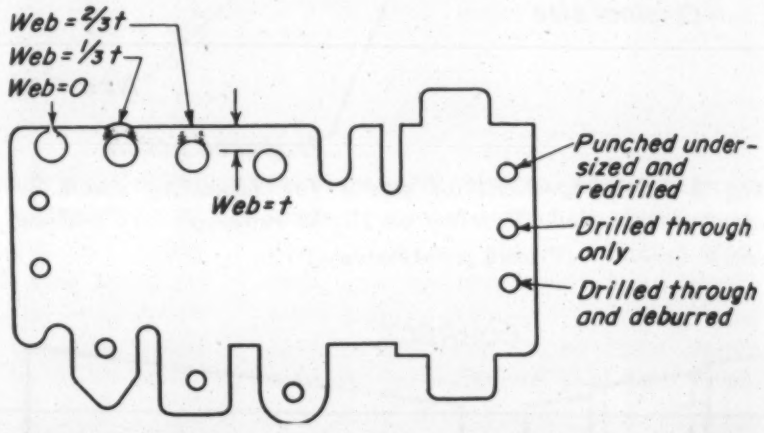
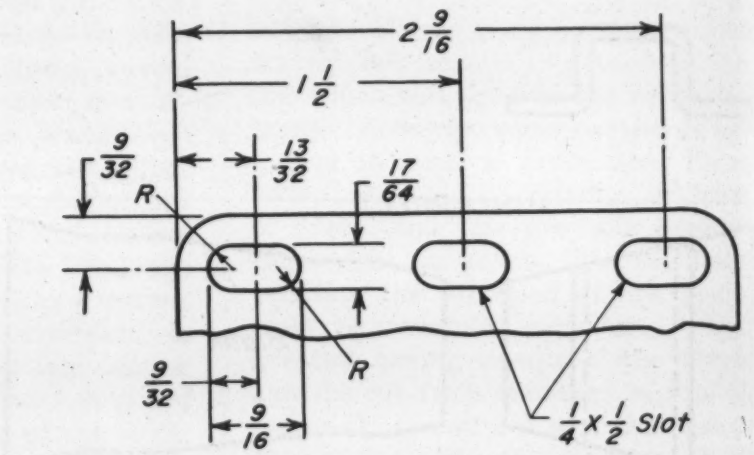
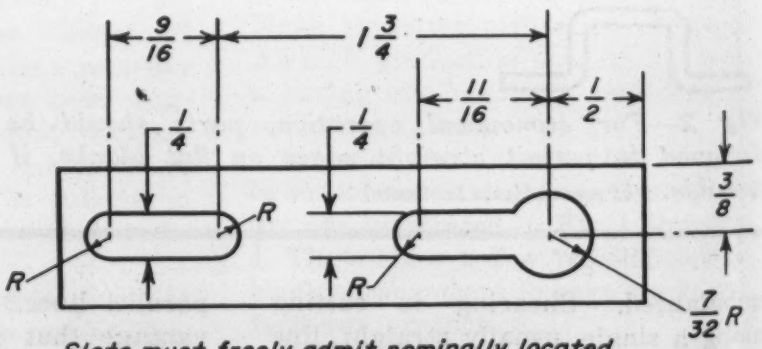


Fig 9—*Holes may be punched or drilled, some of the possible combinations being indicated here. In punching, distance from the edge will determine whether distortion occurs.* (Dayton Rogers Mfg. Co.)





Slots must freely admit nominally located gage pins 0.010 under minimum slot size

Fig 10—*Slots should be dimensioned to show requirements plainly.* (Pressed Metal Institute)

dimensions as accurately as can be done with blanking. Notches are potential starting points for failures and should not be specified with a sharp vertex in parts subjected to severe stress conditions. Suggestions for notching are given in Fig 5.

Lancing and slitting

Lancing is a combined cutting and forming operation of limited application. It is used to form a louver or similar shape. The cut is usually a straight line, and bending is restricted to a displacement not more than the thickness of the stock. Louvers can be lanced and formed in one operation. Design suggestions are given in Fig 6.

Slitting is a somewhat similar operation but instead of cutting the stock along a straight line, it often cut around a portion of the periphery. The tab thus formed is bent in a subsequent operation.

Holes in stampings

In blanking and the related operations just described, the shape cut from the stock was the desired part. In the group of cutting operations discussed here, the shape cut from the blank is scrap material. If holes are required in stamped parts, they are formed by punching, extruding or piercing, the distinction being shown graphically in Fig 7.

In designing for punched holes, it is frequently forgotten that only part of the stock thickness is sheared cleanly, the balance being torn out by the pressure exerted. The hole produced by punching has a taper, not parallel sides. A rule of thumb is that not more than one-half the stock is sheared and, as shown in Fig 8, the hole diameter below the sheared area is significantly larger than that produced by the punch. This point is particularly important if the hole sides are required to act as bearing surfaces; a subsequent reaming operation may be required to obtain parallel walls.

Round holes are the cheapest and easiest shape to machine on dies and the easiest to hold within tolerance limits. Hole sizes should be standardized to reduce costs, and preferably a minimum number of sizes should be used on a single blank. If slots are required, round ends can be made cheaper and easier than square ends.

There is a lower limit to hole size below which it is not economical to punch holes because of excessive punch breakage. For mild steel this limit is roughly the stock thickness; generally, it is preferable to drill holes of smaller diameter. However, some producers say that punching fine holes is not impractical, but depends on the metal. Strasser suggests that the following formula can be used:

$$\text{Min hole diameter (in.)} = \frac{4\,s\,t\,p}{0.67\,c}$$

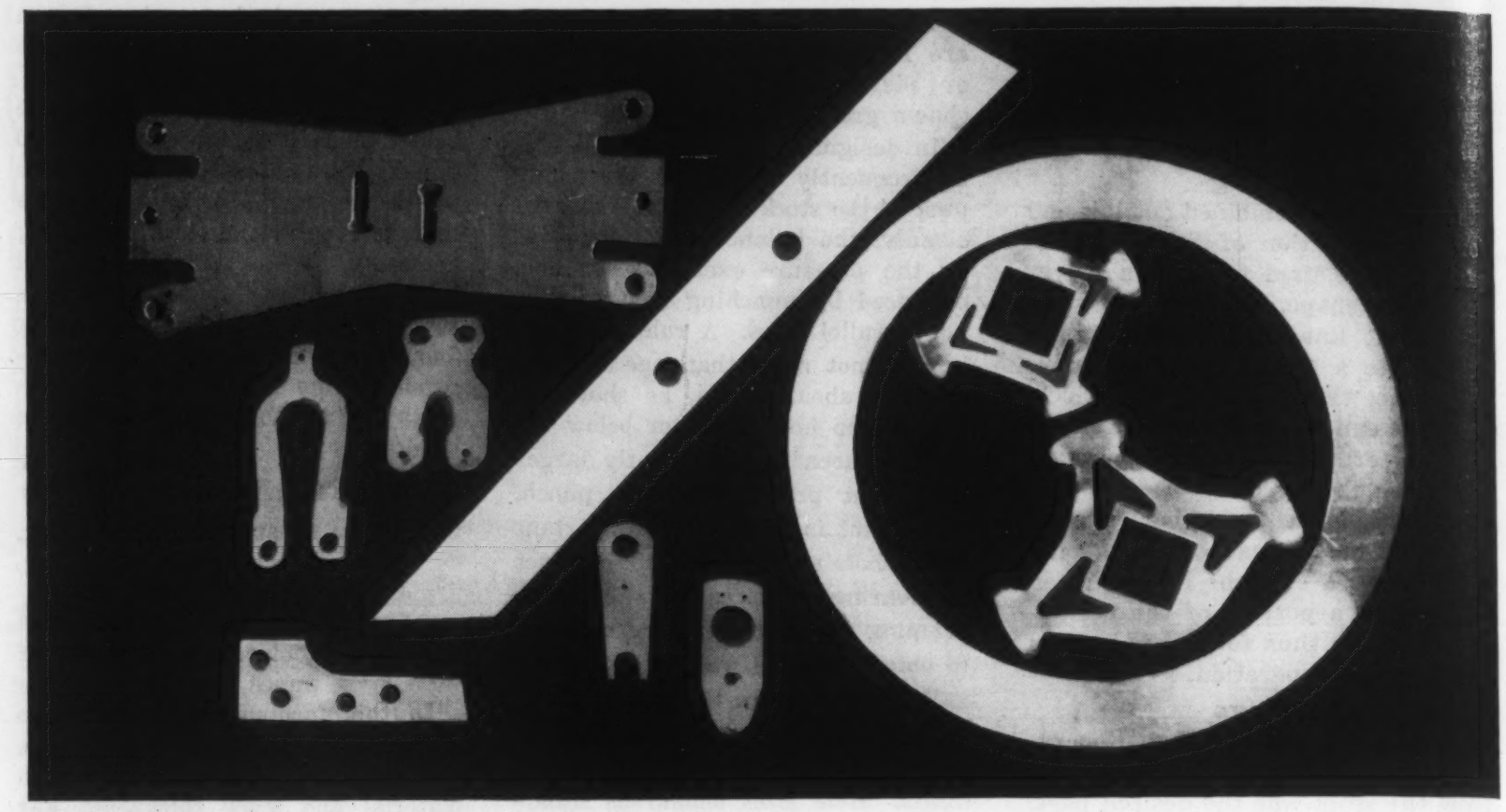
where s = shear strength of stock, psi
t = stock thickness, in.
p = punch penetration, %
c = compressive strength of punch, psi

In this formula, the penetration of the punch before the slug is torn out must be determined for each material and stock thickness. For mild steel some values are:

Skyscraper skin *will be made of large panels like this one formed from stainless steel.*

Commercial Shearing & Stamping Co.

Cutting operations were used to produce these blanks and parts



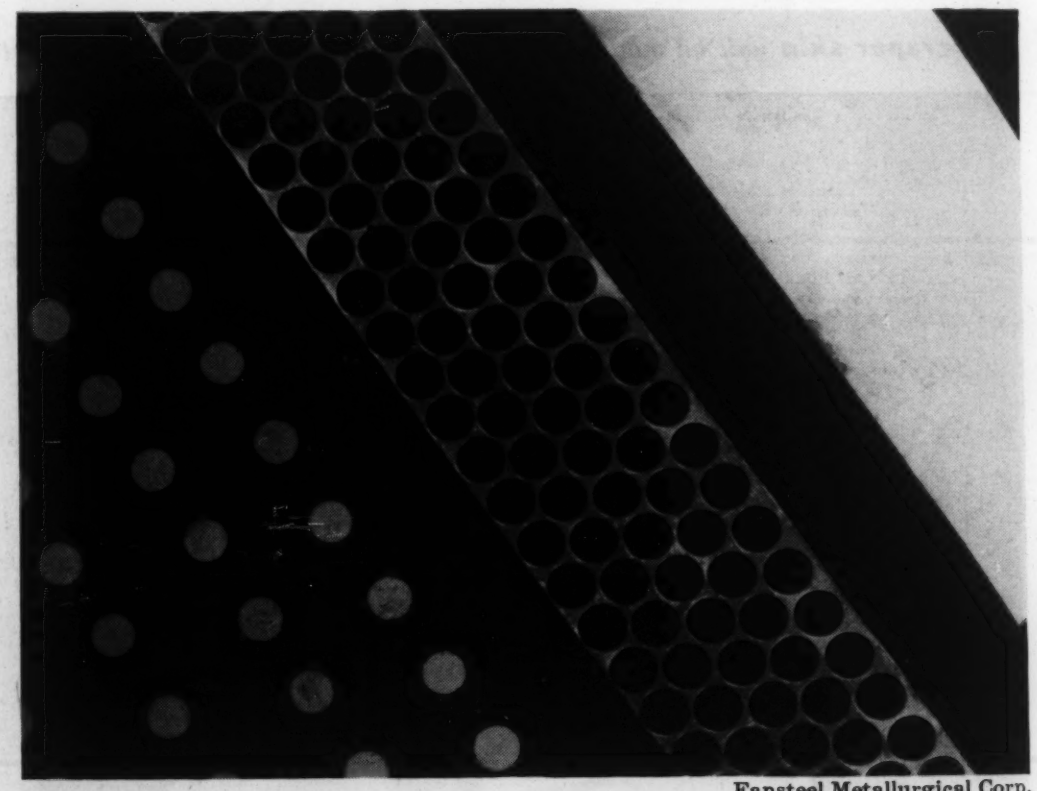
Flat springs *and other flat parts produced in one operation.*

Stock Thickness, in.	Penetration, %
1/32	87
1/8	62
1/4	50
3/4	30

Holes should be located with the distance between the outside edge of the sheet or the distance between two holes not less than twice the sheet thickness for stock 0.06 in. thick or heavier. Metal below this thickness requires a distance not less than ⅛ in. Effects of hole location are indicated in Fig 9.

Hole clearances are determined by service requirements. For a cold rivet, the hole should be 1/64 in. over the nominal rivet size. Bolt clearances are usually 1/64 to 1/32 in. for general service requirements, but smaller for aircraft service.

Threaded holes—If holes are to be threaded, stock thickness must be no less than one-half the thread diameter for steel or brass, and at least two-thirds the thread diameter for softer metals such as aluminum. However, it is not always necessary to increase the stock thickness to achieve this objective. Extrusion of the stock (see Fig 7) often increases thickness at the hole to the required value.



Fansteel Metallurgical Corp.

Simple *round blanks and perforated sheet are used in various products.*

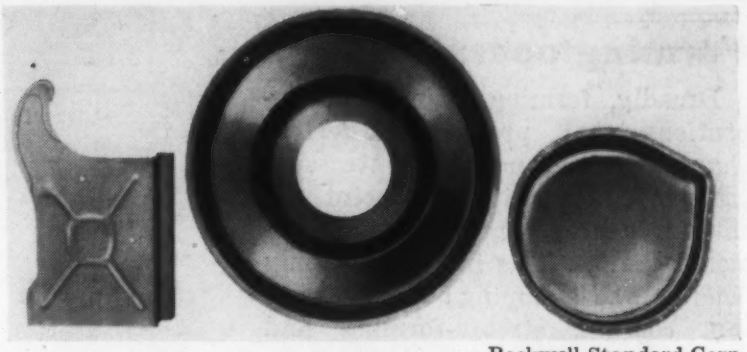
If two stampings are to be fastened together, it is desirable to compensate for inaccuracies during manufacture by employing a round hole in one part and a slot in the other. Slots are also used to provide for adjustment in overall length and width dimensions. Depending on their function, slots may or may not require gage inspection. Slots should be specified as shown in Fig 10.

The problem of holes near bends

Forming operations were used to produce these stampings

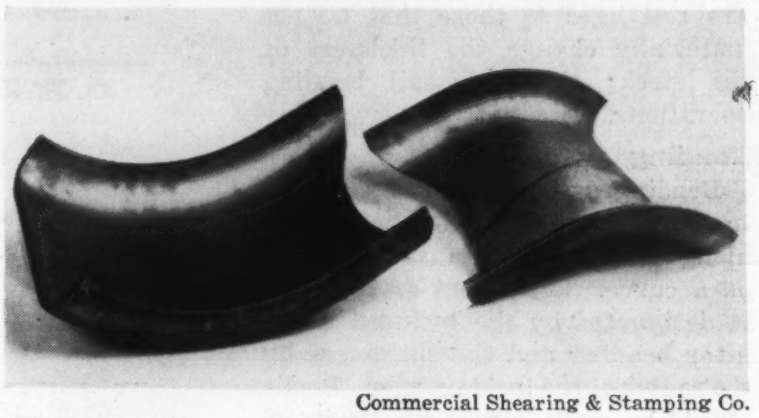
Sylvania Electric Products, Inc.

Small *stampings for the electronic industries are produced from materials ranging from steel through the precious metals.*



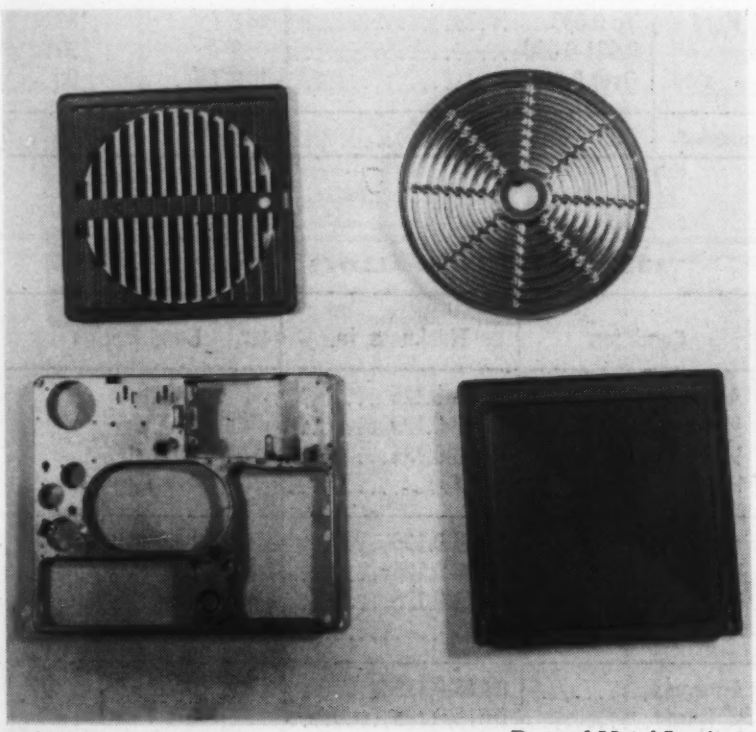
Rockwell-Standard Corp.

Gages *formed range from slight to heavy.*



Commercial Shearing & Stamping Co.

Open *stampings, over-formed to allow for springback, were formed from 1/4-in. steel. Tolerances of ±1/32 in. were held.*



Pressed Metal Institute

Shallow *formed parts—punched, ribbed and lanced—are typical of stampings.*

Aluminum Co. of America

Perforated and bent *aluminum serves as material for acoustical ceilings.*

requires careful consideration because improper location can result in distortion and failure of the hole to function as intended. This portion of designing for hole location will be discussed under forming operations.

Limitations

Limitations of the cutting group of operations include:

1. Selection of ductile materials requires a minimum tolerance of 10 to 15% of stock thickness for size and shape of sheared details. Closer tolerances are obtainable if the first operation is followed by shaving, broaching, boring or reaming.

2. Tolerances on location of details cannot be closer than those on

size and shape and often must be greater.

Forming operations

Broadly, forming includes all operations that produce a desired shape in sheet metal by stressing the metal beyond its yield point and thus producing a permanent dimensional change. This includes not only bending and stamping but also drawing, coining, stretch-forming and similar operations. For the purpose of this manual, forming operations are restricted to those that do not materially change the thickness of the stock; these are all bending operations.

Bending

Bending, as employed in the stamping process, usually implies bends along a straight line rather than on a curve. The extent of the bend is designated by the included angle after bending and the sharpness by the radius at the inside corner. Bends should be made across the grain, if possible, or at 45 deg to the rolling direction. Bends parallel to the grain should be avoided. Using the largest possible bend radius is good practice because this permits greater latitude in material selection and often assures better bends (Fig 11).

Although minimum bend radii have been established for some materials and suggestions are given in Tables 1, 2, 3 and 4, minimum values are generally developed only by trial. As a first approximation, Strasser suggests multiplying the stock thickness (in.) by:

0.3 to 0.7 for soft metals (min stock thkn 0.02 in.).
0.6 to 1.2 for hard metals (min stock thkn 0.06 in.).
2.0 to 3.0 for very hard metals.

If cracking or tearing occurs on bends made with these values, he suggests trying modifications such as:

1. Increasing the bend radius.
2. Barrel finishing the blanks to remove rough edges before bending.
3. Annealing the blanks.
4. Selecting a more ductile material.

The total length required for bending is the sum of the two legs plus the bend allowance. Depending on the angle and sharpness of the bend, this length can vary considerably. Calculations can be made by the formulas given in Fig 12.

Sometimes costs can be reduced by using thinner materials than had

Suggested minimum bend radii

TABLE 1—AUSTENITIC STAINLESS STEELS

Steel	Condition	Thickness Range, in.	Bend Radius	Bend Angle, deg
301, 302, 304	Annealed	All	½T	180
	¼ Hard	To 0.050	½T	180
		Over 0.051	1 T	90
	½ Hard	To 0.050	1 T	180
		Over 0.051	1 T	90
	Hard	To 0.030	2 T	180
		0.031-0.050	1½ T	90
316	Annealed	All	½ T	180
	¼ Hard	To 0.050	1 T	180
		Over 0.051	1 T	90
	½ Hard	To 0.030	2 T	180
		0.031-0.050	3 T	90
		Over 0.051	2 T	90
321, 347	Annealed	All	½ T	180

TABLE 2—ALUMINUM ALLOYS

Alloy and Temper	Condition	Thickness, in.	Bend Radius
1100-O	Annealed	0.016-0.125	Sharp
1100-H12	¼ Hard	0.016-0.125	Sharp
1100-H14	½ Hard	0.016-0.125	Sharp
1100-H18	Hard	0.064	1-2 T
3003-O	Annealed	0.016-0.125	Sharp
3003-H12	¼ Hard	0.016-0.125	Sharp
3003-H14	½ Hard	0.016-0.125	Sharp
3003-H18	Hard	0.064	1½-3 T
5050-O	Annealed	0.016-0.125	Sharp
5050-H32	¼ Hard	0.016-0.125	0-1 T
5050-H34	½ Hard	0.016-0.125	0-1 T
5050-H38	Hard	0.064	1½-3 T
5052-O	Annealed	0.016-0.125	Sharp
5052-H32	¼ Hard	0.016-0.125	0-1 T
5052-H34	½ Hard	0.016-0.125	½-1½ T
5052-H38	Hard	0.064	1-2 T
6061-O	Annealed	0.016-0.125	Sharp
6061-T4	Heat Treated	0.064	½-1½ T
7075-O	Annealed	0.016-0.032	0-1T
7075-T6	Heat Treated	0.064	3-5T

TABLE 3—CARBON AND LOW ALLOY STEELS (In.)

SAE Steel ↓	Thickness, in.						
	0.016	0.025	0.035	0.050	0.062	0.109	0.187
1020-1025	0.03	0.03	0.06	0.06	0.06	0.13	0.19
1070-1095	0.06	0.06	0.09	0.13	0.16	0.31	0.50
4130[a]	0.03	0.03	0.06	0.09	0.09	0.16	0.31
8630[a]	0.03	0.03	0.06	0.09	0.09	0.16	0.31

[a]Annealed.

TABLE 4—COPPER ALLOYS

Alloy	Temper	Nominal Thickness, in.	Minimum Suitable Radius of Punch, in.		
			Bend Perp to Roll Dir	Bend 45 Deg to Roll Dir	Bend Par. to Roll Dir
Copper	Half Hard	0.020	1/32	1/32	3/64
	Extra Hard	0.020	1/64	1/32	1/32
Red Brass, 85%	Drawing Anneal	0.005-0.064	Sharp	Sharp	Sharp
	Half Hard	0.020-0.050	Sharp	Sharp	Sharp
	Hard	0.040	1/64	1/32	3/32
	Extra Hard	0.040	1/16	3/32	1/32
	Spring	0.040	1/16	3/16	1/2
Low Brass, 80%	Hard	0.020	1/32	3/64	1/16
	Spring	0.020	1/32	1/8	3/16
Cartridge Brass, 70%	Half Hard	0.005-0.050	Sharp	Sharp	Sharp
	Hard	0.040	1/64	1/32	3/64
	Extra Hard	0.040	1/32	5/32	7/32
	Spring	0.040	1/16	<1/4	<1/4
	Extra Spring	0.040	1/8	<1/4	<1/4
Yellow Brass	Half Hard	0.005-0.090	Sharp	Sharp	Sharp
	Hard	0.040	Sharp	Sharp	1/32
	Extra Hard	0.040	3/64	1/8	3/16
	Spring	0.040	3/64	7/32	<1/4
Medium Leaded Brass	Half Hard	0.040	Sharp	Sharp	Sharp
Phosphor Bronze, 5%	Half Hard	0.020-0.070	Sharp	Sharp	Sharp
	Hard	0.040	1/16	1/16	1/8
	Extra Hard	0.040	1/16	1/8	—
	Spring	0.040	3/32	—	—
Phosphor Bronze, 8%	Half Hard	0.005-0.064	Sharp	Sharp	Sharp
	Hard	0.040	1/32	1/8	—
	Extra Hard	0.040	3/64	5/32	<1/4
	Spring	0.040	3/32	1/4	1/2
	Extra Spring	0.064	5/32	<1/4	<1/4
High Silicon Bronze	Hard	0.020	1/32	1/32	1/16
	Spring	0.020	3/64	3/32	3/16
Nickel Silver 65-18	Half Hard	0.040	—	1/64	1/32
	Hard	0.040	1/16	1/16	1/16
	Extra Hard	0.040	1/8	1/8	3/16
	Spring	0.040	5/32	3/16	7/32
	Extra Spring	0.040	5/32	7/32	1/4
Nickel Silver 55-18	Half Hard	0.040	1/16	1/16	1/16
	Hard	0.040	1/16	1/16	3/32
	Extra Hard	0.040	1/8	5/32	3/16

Source: *Wilkins and Bunn.*

been considered practical. Use of reinforcing ribs, flanges or curled edges can often increase the part strength sufficiently to permit the use of very thin stock. An example is the use of aluminum foil for containers for food products. Bends for ribs should be made across the grain if possible; suggested dimensions for ribs are given in Fig 13.

Certain precautions are required in designing flanges. Length of the bent leg must be adequate to avoid distortion. Minimum height ranges from two to four times the stock thickness depending on such factors as bend radius, material and stock thickness. Tapered flanges should not taper to the face, thus producing a sharp point, but should be cut off so that the narrowest part is about twice the metal thickness. Outside flanges and flanges around openings should also have a height of twice the metal thickness. Hemmed edges should be notched at the corners to eliminate gathering during flanging. Design suggestions are given in Fig 14 through 17.

Holes in bent parts

The location of a hole near a bend must be planned carefully. If a hole is too close to the bend, distortion will result and the shape of the hole may be changed enough to prevent functioning of the part. It is preferable to avoid distortion by keeping hole edges at least as far from the inside radius of the bend as twice the stock thickness (see Fig 18). If this is not possible, and the design requires a hole within the area where distortion occurs, it can be punched after bending. This secondary operation increases the cost considerably.

Springback

During a forming operation, the contour of the part matches that of the tools, but upon release of the load the part assumes a different shape because of the release of elastic stresses. The distortion that occurs is called *springback*. This distortion must be taken into account if the final shape is to correspond with that of the original design.

Sachs states that springback is independent of metal thickness and depends only on the ratio of bend radius to stock thickness. Springback factors for a number of metals are given in Fig 19.

Tools can be designed to compensate for springback by causing over-

Design suggestions for formed parts

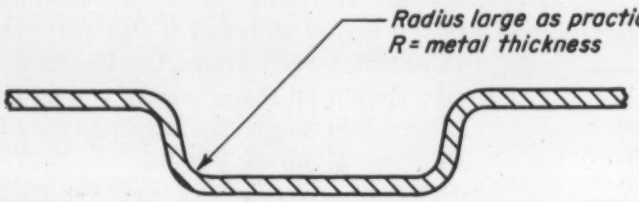
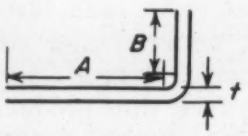
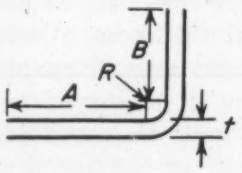


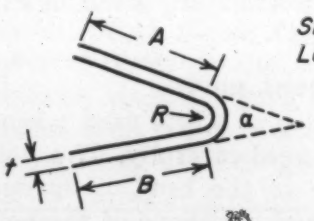
Fig 11—*Inside radii at bends should not be less than the stock thickness; larger radii are desirable.* (Pressed Metal Institute)



Single 90-deg bend with sharp punch (0.015 in. max rad)
Length = A + B + 0.4t



Single 90-deg bend with round-nosed punch (0.015 in. min rad)
Length = A + B + 1.57(0.4t + R)



Single bend at acute angle
Length = A + B + 0.0175α(0.4t + R)

Fig 12—*Length of stock required for bending at various angles is calculated as indicated above.* (Strasser)

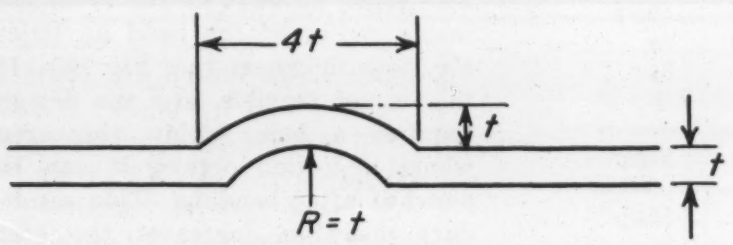
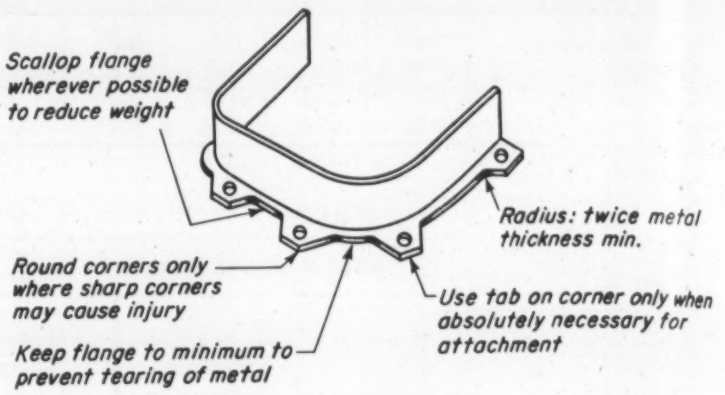
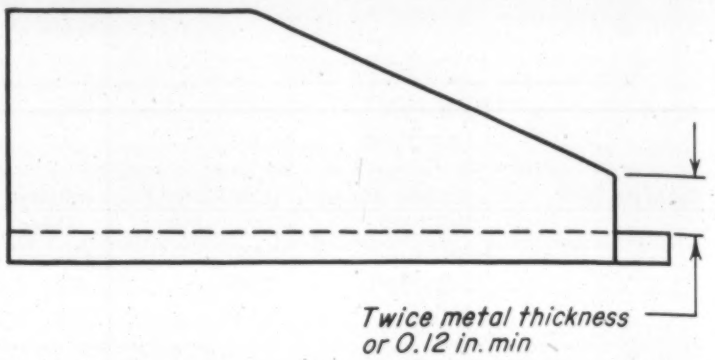
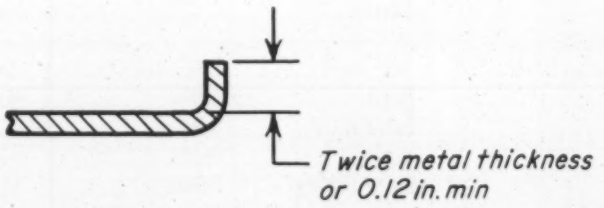


Fig 13—*Strengthening ribs should be dimensioned as indicated and handled like simple bends.* (Strasser)


Scallop flange wherever possible to reduce weight
Radius: twice metal thickness min.
Round corners only where sharp corners may cause injury
Use tab on corner only when absolutely necessary for attachment
Keep flange to minimum to prevent tearing of metal





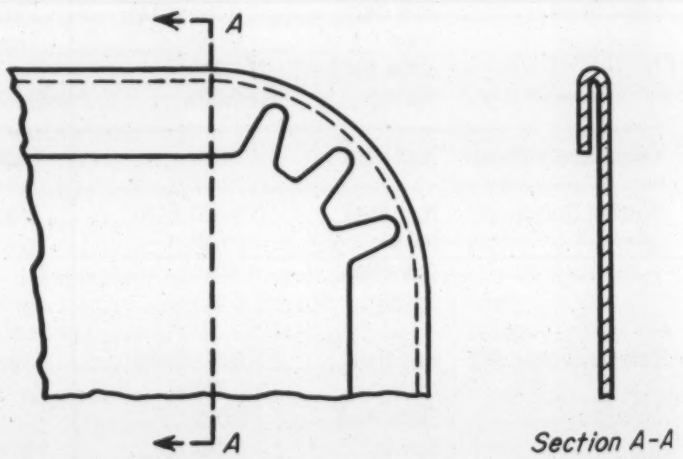


Fig 14—*Properly designed flanges eliminate troubles in production.* (Pressed Metal Institute)

bending of the part. If the parts are being produced from widely used metals such as brass, for example, the properties are sufficiently well-known to make compensation relatively easy. However, in working with the newer metals, such as titanium, springback has been responsible for many production difficulties.

Tolerances

In deciding on the tolerances required for a given part, consideration must be given to the function of the stamping, to the product quality (economics permit a high cost item to be held to closer tolerances than an inexpensive one), to its mating with other parts, and to similar considerations. The closer the tolerance, the greater is the cost of production. A major factor in keeping costs in line is to specify close tolerances only on dimensions that require them for proper functioning of the part. For example, there is no point in specifying close distance and diameter tolerances on

Fig 15—*To facilitate trimming, the minimum flange width should be twice the metal thickness. Absence of a flange requires an expensive trimming operation because trimming must be done on a horizontal plane.* (Pressed Metal Institute)

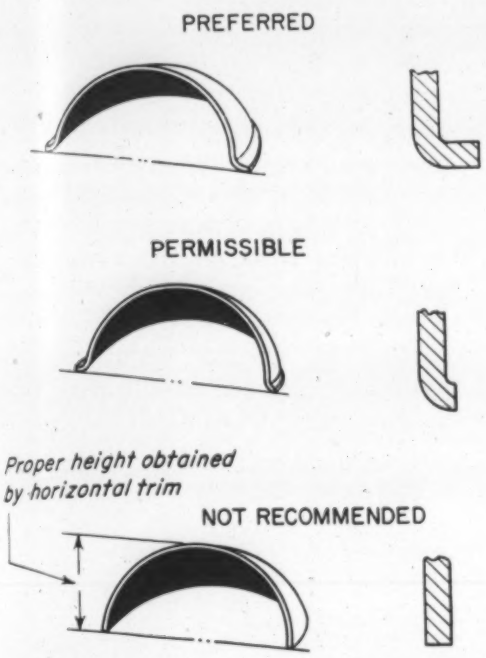


Fig 16—*Flanges that extend over only a portion of a highly stressed part should be stress relieved by notching or drilling a circular hole to prevent tearing.* (Pressed Metal Institute)

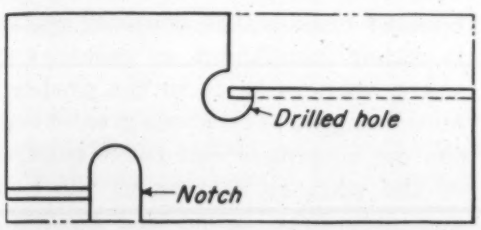
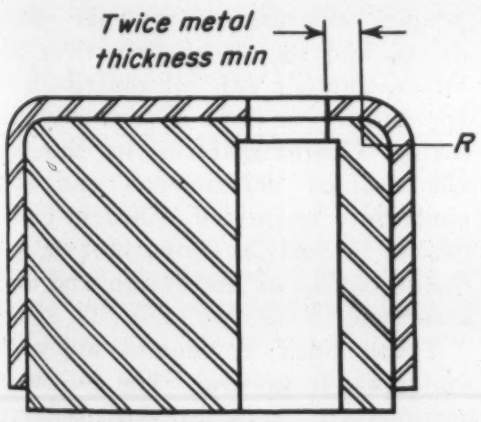


Fig 18—*To avoid distortion of a hole during bending, the distance from the edge of the hole to the tangent point of the radius should be at least twice the metal thickness.* (Pressed Metal Institute)



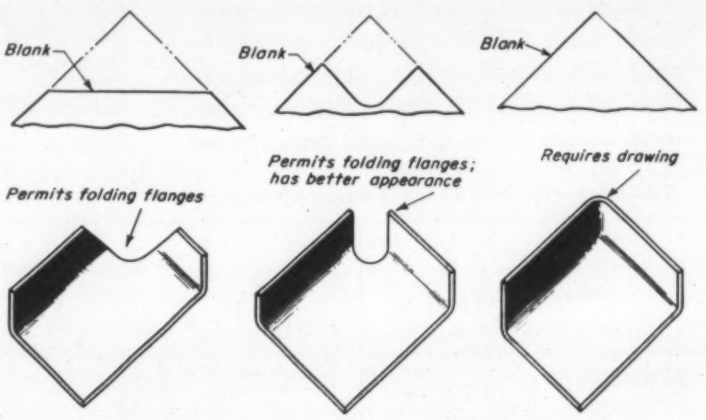


Fig 17—*In the design of box-shaped parts, if strength is not involved, forming is less expensive than drawing.* (Pressed Metal Institute)

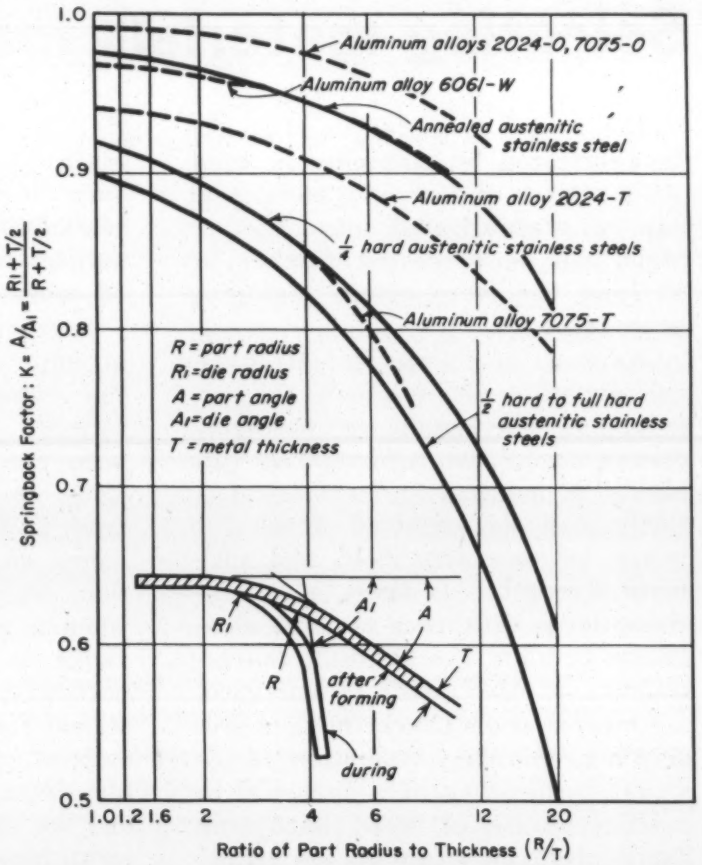


Fig 19—*Springback of various sheet materials.* (Sachs)

holes that are punched merely for the purpose of reducing the weight of the part. Use of widest possible tolerances on overall length, width, depth, diameter of formed edges, dimensions of flanges and distance between holes increases production rate and lowers costs. When one part mates with another, the same tolerances should be employed for both.

It is usually not economical to hold tolerances on the size of a blanked part closer than ±0.003 in., and often tolerances of 15% of the sheet thickness must be allowed for the softer metals. Although tolerances of ±0.001 in. can be held on holes, hole locations and outside diameters, such tight requirements call for careful handling and increase production costs; production tolerances of ±0.005 in. can be held but ±0.010 in. are preferable. Suggested tolerances on punched holes are given in Table 5.

Parts can generally be held to

closer tolerances on multislide than on conventional machines. For example, formed dimensions can be held to ±0.001 to ±0.005 in. and angles to ±½ to ±1 deg.

Tolerances allowed on hole locations near bends can have a significant effect on the cost of production. For example, if the tolerance between the bend and the hole center is ±1/64 in. the hole can be punched before bending, but to hold a tolerance of ±0.002 in. would require punching after bending with higher die cost and thus increased cost for the part.

Finish — Specifying unnecessary tolerances on finish also increases costs. If the part is not exposed after assembly, the finish need not be as good as that on an exposed part and, as a matter of fact, may be needed only for protection. A case in point is an instrument panel that was rejected for finish. Examination revealed that one side of the stock had been stenciled with the name of the producer of the material. Viewing this side at an angle, after painting, it was possible to see the letters through the coated surface. To prevent this show-through of the letters, the side had to be finished at an additional expense. However, this side of the panel was installed on the inside of the instrument and required protection only. In this case, rejection caused a large monetary loss that was actually not necessary.

TABLE 5—SUGGESTED TOLERANCES ON PUNCHED HOLES IN LOW CARBON STEEL[a]

Metal Thickness, in. ↓	Nominal Diameter of Hole, in.				
	Up to 1	>1 up to 3	>3 up to 10	>10 up to 20	>20
Up to 0.015	0.0015	0.003	0.004	0.006	0.008
>0.015 up to 0.031	0.003	0.004	0.005	0.008	0.010
>0.031 up to 0.062	0.004	0.005	0.007	0.010	0.015
>0.062 up to 0.125	0.010	0.012	0.015	0.020	0.025
>0.125	0.020	0.025	0.030	0.035	0.040

[a]Tolerances (in.) are plus or minus. Source: Pressed Metal Institute.

Selecting materials for stampings

The range of materials that can be fabricated by stamping is wide. As a matter of fact, any metal that can be prefabricated into sheet or strip can be processed further by at least the more simple stamping procedures.

Influence of properties—Mechanical properties give a clue to the performance of metals in stamping operations. Some indication of the ability of a metal to form satisfactorily can be obtained from the range between the yield and ultimate strengths. If there is a relatively large difference and the elongation is high, the forming characteristics of the material are good.

However, these characteristics give only a preliminary indication of the actual formability of a material in practice. Rate of work hardening has a profound effect on the reduction that can be given to a material before annealing is required, and is more important than the mechanical properties of annealed material. The metals work harden to varying degrees when subjected to stresses in the plastic range. As the hardness of a metal increases, its ductility diminishes; consequently the rate of work hardening governs the total reduction that can be given before internal stresses become great enough to require stress relief by annealing. Fig 20 shows the increase in hardness of various metals resulting from cold work and indicates the relative workability of these materials. However, the only satisfactory method of determining the workability of a new material is to subject it to trial runs of the type of operation involved.

A frequent cause of trouble is the attempt to make reductions beyond the capacity of the metal being formed. For example, 3003 aluminum has a nominal elongation of 25%; commercial lots may vary from 23 to 30%. If tooling is established on the basis of 25% elongation, high scrap losses may result when a lot on the low side of the range is received. To avoid this possibility, tooling should be designed for the low side of the commercial range. In the case of 3003 aluminum, if tooling was established on the basis of 20% elongation, scrap losses probably would be about 0.5%; if the same part were tooled for 27% elongation, scrap losses could easily reach 5 to 8%. In the latter case, there is nothing wrong with the material; the tooling is wrong because it was designed too close to the working limits of the material.

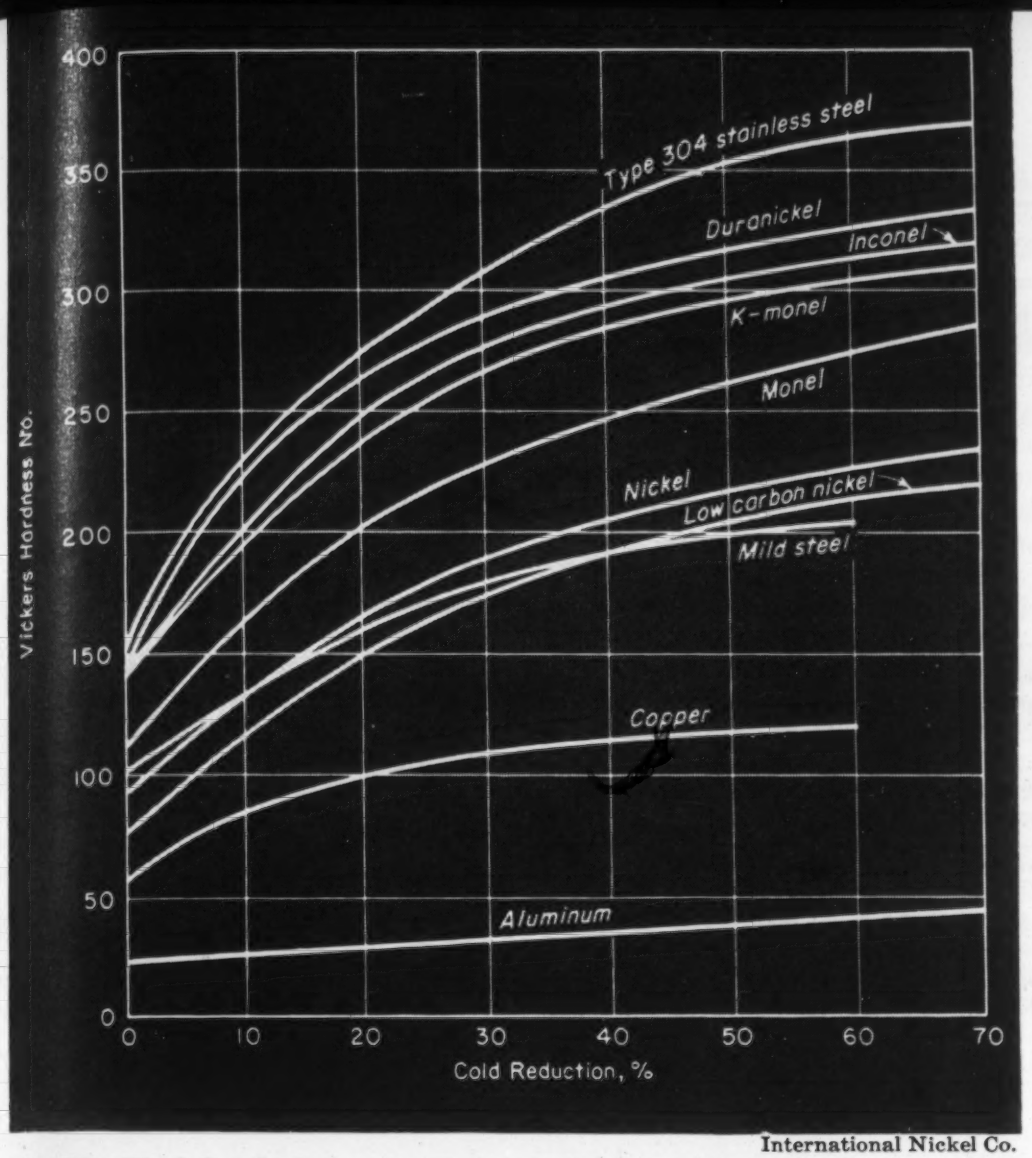
Commercial tolerances—Further, a material may be specified as 0.060 in. thick, for example, but it must be recalled that this is the nominal thickness and commercial material will vary from perhaps 0.0568 to 0.0635 in. If these variations are not taken into account in designing, trouble may result. Thickness variation in sheet metals can cause parts made on the same tooling to be different in shape because of springback or because the pressure applied is either insufficient or excessive at sharp corners to form the predetermined angles. Thickness greater than the die clearance can cause marring of the part or scoring of the tools and may even cause tool breakage.

Breakage in forming operations is not always caused by the quality of the material. Poor die design, improper clearance, improper holddown, and too great reductions between anneals can all contribute to the failure to form a part satisfactorily. Use of material too thin for the desired deformation can also contribute to failure. Efficient lubrication is just as important in reducing scrap as die design and construction.

These brief comments apply to materials in general. The following sections are concerned with some of the characteristics of specific materials that are used for stampings.

Ferrous metals

Stampings are produced from carbon steels ranging from about 0.08 to 0.90% carbon, from various low alloy steels, and from stainless and heat resisting grades. However, the major production is confined to several modifications of low carbon material.



International Nickel Co.

***Fig 20**—Work hardening rates of metals differ greatly, a factor that must be considered in selecting a material for forming operations.*

Low carbon steel

Steel sheet and strip for forming operations generally contain less than 0.10% carbon. Rimming steel is used for most of these operations. In the production of this type of steel, dissolved gases separate as the liquid metal freezes. As a result, a thick rim is formed having lower carbon and manganese content than the remainder of the ingot. For severe forming operations, killed (deoxidized) steel is preferred. In producing killed steel, little gas evolution occurs and composition is more uniform than in rimmed steels.

These characteristics of the two types of steel have definite effects on the sheet and strip produced. Rimmed steel has a thicker skin, and sheet produced from this material is relatively free from surface defects; killed steels have a thinner skin that may be ruptured during hot rolling, producing seams or surface laminations. For this reason, rimmed steel is usually selected if the surface condition is important.

Either cold or hot rolling can be used in reducing the steels to the desired thickness. Cold rolled rimmed steel is generally given a process anneal at 1100 to 1400 F to develop suitable forming properties. Hot rolled material is generally normalized at about 1650 F, but may be subsequently process annealed to obtain maximum softness. Generally rimmed and killed steels are flattened by rolling to a predetermined reduction to eliminate the tendency to develop stretcher strains during forming. Properties of several grades are given in Table 6.

Stretcher strains and aging—Stretcher strains are characteristic markings that appear on the surface of low carbon steel that has been annealed as a final mill operation. These lines appear during the early stages of forming; in compression they are raised, whereas in tension they are depressed. Although they have no harmful effect on the strength of the part, they are usually cause for rejection of stampings that are exposed in service because the markings show through surface coatings. Stretcher strains can be eliminated by a cold reduction (temper pass) of about 1% after the final anneal. Elimination is generally permanent in killed steels, but the markings almost always return in rimmed steels if these steels are permitted to age before forming.

Rimmed steel has a tendency to harden by aging and must be used in a reasonable time after the final rolling to avoid forming difficulties. Aging begins immediately after the final cold rolling but is usually not a serious problem until about a month has elapsed. The extent to which aging affects the forming properties depends on the properties of the sheet at the time of rolling and is unpredictable. One rimmed steel may not age sufficiently to have any effect on formability whereas another, sufficiently ductile to be

TABLE 6—SOME PROPERTIES OF SHEET AND STRIP STEELS

Steel	Condition	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %	Rockwell Hardness	Olsen Cup Depth, in.
CARBON STEELS						
Cold Rolled[a]	Annealed	42	35	37	B50	0.38
	Temper Passed[d]	44	35	35	B55	0.37
Cold Rolled[b]	Annealed	41	32	41	B45	0.40
	Temper Passed[d]	42	30	39	B48	0.39
Cold Rolled[c]	Temper Passed[d]	41	25	41	B45	0.40
Hot Rolled	Normalized	48	30	40	B50	0.42
	Norm., Annealed	48	25	45	B45	0.42
STAINLESS STEELS						
Type 201	Annealed	105	55	55	B90	—
Type 301	Annealed	90	40	50	B85	0.4-0.5
	¼ Hard	125	75	12	C25	—
Type 304	Annealed	85	35	50	B80	0.4-0.5
Type 305	Annealed	85	38	50	B80	—
Type 410	Annealed	65	25	25	B80	0.3-0.4
Type 430	Annealed	75	45	25	B80	0.3-0.4

[a]Commercial quality, rimmed (0.036 in. thick).
[b]Drawing quality, rimmed (0.036 in. thick).
[c]Drawing quality, killed (0.036 in. thick).
[d]Temper passed refers to a slight cold reduction (about 1%) after the final anneal.

used in difficult forming operations as received, can age enough in a month to be unsuitable for making simple bends. Effect of aging is shown in Table 7 for a steel of doubtful drawing quality.

Steel selection—Killed steel has better mechanical properties than rimmed steel, and also better forming properties. It is usually free from aging and thus can be stored for long periods without detrimental effects on its drawing qualities. However, killed steel's surface properties are inferior to those of rimmed steel. Most producers of stampings restrict the use of killed steel to severe forming operations and to low volume parts for which the material cannot be used before aging would begin in a rimmed steel. Killed steel is intended for applications in which freedom from changes in mechanical properties (aging) are required, where stretcher strains are not permitted, or for operations too severe for rimmed steel of drawing quality. It carries a premium price.

Severity of the operation generally determines the quality of steel that is required. Rimmed steel is cheaper than killed, and of the rimmed grades commercial quality is cheaper than drawing quality. Carbon content is also a factor in cost. The 1008 grade is usually preferred for all stamping operations because it is cheaper than 1020 or 1030. The latter grades are selected for stressed parts requiring higher yield and tensile strengths than are obtainable with 1008.

It is good practice to use the lowest quality steel that will produce satisfactory results. An indicator of proper selection is scrap loss. If the loss ranges between 1 and 2%, proper selection has been made. If there is practically no scrap, a lower grade of steel should be investigated because of the possibility of reducing the cost of the part. If scrap losses are much higher than 2%, a higher quality steel may be required.

TABLE 7—EFFECT OF AGING ON PROPERTIES OF A FAST-AGING, COLD ROLLED 1008 RIMMED STEEL

Condition ↓	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %	Rockwell Hardness	Olsen Cup Depth, in.
As Received	49.6-50.4	36.1-38.5	34.5-35.5	B50-52	0.405
Aged 21 Days	49.9-51.0	37.5-40.3	33.5-34.5	B53-54	0.400
Aged 70 Days	52.1-52.8	41.1-44.0	32.0-33.0	B55-56	0.395-0.400
Aged 139 Days	51.8-52.1	40.6-42.9	32.5-33.0	B56-57	0.395-0.405

Source: *Metal Progress*, Aug '55.

Stainless steels

Even in the dead-soft condition many stainless steels are 1½ times as hard and strong as carbon steels (see Table 6). Therefore greater power is required in forming.

The austenitic grades have better ductility, but higher work hardening

***Combined** blanking, forming, trimming, sizing and flanging operation on a recently developed machine forms a shallow can body in one stroke.*

Kaiser Aluminum & Chemical Sales Co.

TABLE 8—PROPERTIES OF SOME DEEP DRAWING METALS

Metal[a] ↓	Tensile Strength, 1000 psi	Yield Strength (0.2% offset), 1000 psi	Elong (2 in.), %	Rockwell Hardness	Olsen Ductility			Pressure Factor at 0.375-In. Cup Depth
					Depth of Cup, in.	Beam Load, 1000 lb		
						At Fracture	At 0.375-In. Cup Depth	
Monel	71	27	52	B58	0.495	11.8	9.1	5.2
Nickel	72	21	47	B46	0.545	11.6	8.3	4.7
Inconel	91	40	44	B74	0.480	13.8	11.1	6.3
Ingot Iron	44	26	49	B38	0.425	6.5	6.0	3.4
Deep Drawing Steel (0.06% C)	46	31	48	B49	0.430	7.5	6.9	3.9
Copper	32	12	68	—	0.490	5.1	3.8	2.2
Aluminum	14	9	41	—	0.430	1.9	1.8	1.0

[a]Thickness 0.062 in.

Source: *International Nickel Co., Tech Bulletin T-19.*

rates, than carbon steels; enough annealing operations must be interposed between forming operations to prevent over-straining with resulting cracking. Type 301 (17 Cr-7% Ni) has the highest rate of work hardening of the 18-8 group. Although in the annealed condition it will form as readily as other austenitic stainless grades, in the first stages of deep drawing annealing will be required more frequently than is necessary with the high nickel grades. Increasing the nickel content above 10% decreases the rate of work hardening, and such grades as type 305 (10 to 12% Ni) are most suitable for severe forming operations. As both chromium and nickel content are increased in the higher alloyed grades, forming difficulties increase because of the higher strengths of these materials. Springback in the austenitic grades is roughly twice that in carbon steels, and tools must be designed to achieve a greater amount of overbending to compensate.

The ferritic and martensitic grades have about the same ductility and work hardening rates as deep drawing carbon steels. However, their higher hardness must be considered in forming operations.

Nonferrous alloys

A wide range of properties is available in the nonferrous alloys—from very ductile materials that can be formed readily by all of the stamping procedures to those that are refractory and can be formed only by simple operations. Some of the common and less common metals are discussed briefly below.

Copper alloys

Most widely used of all nonferrous alloys, and second in use only to the rimmed steels, are Yellow Brass and Cartridge Brass, 70%. These two materials have characteristics so similar that they are used interchangeably in many applications. Probably next in popularity is Red Brass, 85%. All three of these alloys have excellent cold working properties, combining optimum ductility and good strength. The nickel silvers (which are brasses containing from 10 to 18% nickel) also belong in this group. Nickel Silver 65-18 can be worked almost as readily as Yellow Brass.

The coppers, although initially softer than the brasses, have a lower combination of ductility and strength than the brasses and require more careful handling. However, copper work hardens less rapidly than brass and can be cold worked severely with reductions up to 90%.

The various bronzes are higher strength alloys and are more limited in their stamping applications.

Some indication of the relative ease of fabrication of copper and copper alloys can be obtained from the mechanical properties (see Tables 8 and 9). Table 4 gives suggestions for bending.

Aluminum alloys

Only a few aluminum alloys are used in quantity production of stampings. Most stampings are produced from 1100 or 3003 because these alloys have the greatest drawability. Of these, 3003 is usually preferred because it is stronger than 1100 and costs practically the same. Alloy 5052 draws well and gives a considerably stronger part than either of the two alloys mentioned previously. However, it work hardens more rapidly and consequently a smaller reduction per draw is required.

The heat treatable alloys, e.g., 6061 and 7075, work harden at a higher rate than 5052 and are usually selected for only the strongest stampings. Heat treatment must be performed after the forming operation and may result in distortion of the part. Properties of some aluminum alloys are given in Table 9.

Precious metals

The precious metals are used in a variety of stamping operations. Commercial silver and gold are among the softest and most ductile of metals in sheet form and can be cold formed extensively without intermediate anneals. Sterling silver and coin silver are also quite readily formed.

A large variety of gold alloys containing copper, silver, nickel and other elements to impart strengthening or alter the color are also used for stampings. Strength and workability of these alloys varies greatly depending on the alloying elements employed.

Commercial platinum and palladium have forming properties similar to those of nickel. Some of the platinum alloys with rhodium and iridium are difficult to work, particularly if they contain relatively high additions of the alloying metals. Palladium-silver alloys have good workability but palladium-copper or palladium-platinum alloys vary widely in their working characteristics. Properties are given in Table 9.

Zinc alloys

Zinc sheet alloys (see Table 9) can be formed readily at slightly elevated temperatures. The metal recrystallizes near room temperature

and forming may lead to the development of large grains. For this reason, it is necessary to avoid excess temperature rise during forming and satisfactory results are generally achieved by using rather slow speeds on the presses. Temperatures of 70 to about 125 F are satisfactory.

Other metals

Nickel is somewhat more formable than mild steel and approaches yellow brass in formability, although its higher strength must be taken into consideration. Monel is slightly less ductile than nickel and resembles mild steel in formability. The stronger nickel alloys approach stainless steel in their formability characteristics. Properties of these alloys are given in Tables 8 and 9.

Magnesium alloy sheets (see Table 9) can receive a moderate amount of forming at room temperature but most forming must be performed at elevated temperatures, generally in the range of 300 to 600 F.

Tantalum is readily formed at room temperature into a variety of parts. Commercial titanium has been stamped and formed successfully both at room temperatures and at temperatures in the neighborhood of those used in forming magnesium. Commercial zirconium can be formed by the same procedures. Molybdenum sheet is also formed to some extent at elevated temperatures.

Materials for stampings are by no means limited to solid metals. Precoated metals of various types, including plated, hot dipped and painted, are widely used for decorative or special service requirements.

TABLE 8—PROPERTIES OF SOME ANNEALED NONFERROUS METALS IN SHEET FORM

Metal ↓	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %	Brinell Hardness	Rockwell Hardness	Shear Str, 1000 psi
ALUMINUM ALLOYS (1/16 in.)						
1100-O	13	5[a]	35	23	—	9
3003-O	16	6[a]	30	28	—	11
5050-O	21	8[a]	24	36	—	14
5052-O	28	13[a]	25	47	—	18
6061-O	18	8[a]	22	30	—	12
7075-O	32	14[a]	16	—	—	22
COPPER ALLOYS (0.040 in.)						
Electro Tough Pitch Copper	32-34	10-11[b]	45	—	F40-45	22-25
Gilding, 95%	34-38	10-14[b]	42-45	—	F46-60	28-30
Commercial Bronze, 90%	37-39	10-14[b]	42-45	—	F53-65	28-33
Jewelry Bronze, 87.5%	39-44	11-16[b]	42-46	—	F55-68	29-32
Red Brass, 85%	39-45	10-18[b]	42-48	—	F56-71	31-33
Low Brass, 80%	42-50	12-20[b]	46-52	—	F57-75	32
Cartridge Brass, 70%	44-53	11-22[b]	54-66	—	F54-78	32-35
Yellow Brass	46-53	14-22[b]	54-65	—	F58-78	32-34
Phosphor Bronze, 5%	47-53	19-22[b]	50-64	—	F73-79	—
Phosphor Bronze, 8%	55-62	24[b]	60-70	—	F75-85	—
Nickel Silver, 65-18	58-60	25-30[b]	32-40	—	F85-90	—
Nickel Silver, 55-18	60	27[b]	40	—	F90	—
High Silicon Bronze	56-63	21-30[b]	55-63	—	F76-90	42-45
NICKEL ALLOYS						
Nickel	55-75	15-30[c]	40-55	—	B64 max	52
Duranickel	90-120	35-60[c]	30-50	—	B90 max	—
Monel	70-85	25-45[c]	35-50	—	B68 max	43
K-Monel	90-105	40-65[c]	25-45	—	B85 max	99
Inconel	80-100	30-45[c]	35-55	—	B84 max	59-66
MAGNESIUM ALLOYS						
MIA-O	33	18[a]	16	48	E55	18
AZ31B-O	37	22[a]	21	56	E67	21
AZ51-O	40	21[a]	19	57	E68	20
PRECIOUS METALS						
Gold (18 K)	67	—	42	125	—	—
Gold (14 K)[e]	70-83	43-48[d]	41-58	—	B72-87	—
Gold (10 K)[e]	68-87	38-54[d]	32-41	—	B70-89	—
Platinum	17-19	2-5	25-40	38-52	—	—
Silver	22	8	48	25-35	—	—
Silver (coin)	40	—	—	60	—	—
Silver (sterling)	37	20	42	56	—	—
ZINC ALLOYS						
Zinc (deep drawing quality)[f]	20	—	65	38	—	—
Zinc–1% Copper[f]	24	—	20	52	—	—
Zinc–1 Copper–0.01% Magnesium[f]	28	—	20	61	—	—

[a]0.2% set. [b]0.5% extension. [c]0.2% offset. [d]0.1% set.
[e]Typical values; composition and strength vary widely. [f]Hot rolled.

Acknowledgments

The author is particularly indebted to Harold A. Daschner, managing director of the Pressed Metal Institute, for furnishing much of the information for this manual and for criticizing the manuscript. The author also wishes to acknowledge the assistance received from the personnel and publications of the following organizations:

Ackerman Mfg. Co.
Advance Foundry Co.
Advance Stamping Co.
Aluminum Co. of America
American Nickeloid Co.
Art Wire & Stamping Co.
Commercial Shearing & Stamping Co.
Copper & Brass Research Assn.
Dayton Rogers Mfg. Co.
Firestone Industrial Products Co.
HPL Mfg. Co.
Kaiser Aluminum & Chemical Sales Co.
Pressed Metal Institute
Reynolds Metals Co., Inc.
Rockwell Standard Corp.
Standard Products Co.
Sylvania Electric Products, Inc.
Transue & Williams Steel Forgings Corp.
Waterbury Companies, Inc.
Worcester Pressed Steel Co.

References

Andersen, O. T., and Andersen, J. M., "Economies of Short-Run Stampings Practice," *Iron Age*, Oct 6, '49, p 91.

Crane, E. V., *Plastic Working of Metals*, John Wiley & Sons, New York.

Facts About Stampings, Pressed Metal Institute, Cleveland.

Forming of Austenitic Stainless Steels, International Nickel Co., New York.

Laurich, A. A., "Designing Small Stamped Mechanisms," *Product Engineering*, Jan '51, p 120.

Mikulak, M. J., "Metal Stampings in Small Lots at Reasonable Fabricating Cost," *Product Engineering*, June '47, p 105.

R. A. W., "The Design of Stampings for Quantity Production," *Machinery* (London), May 4, '44, p 487.

Sachs, G., *Sheet Metal Fabricating*, Reinhold Publishing Corp., New York.

Strasser, F.:
"Cheapening Stampings Production by Improving Designs," *Iron and Steel*, May '53, p 183.
"Metal Stampings," *Iron and Steel*, July '56, p 343.
"18 Tips on Practical Stamping Design," *Machine Design*, May '55, p 232.
"Tolerances on Metal Stampings," *Steel Processing*, Aug '55, p 505.
"Are Holes in Stampings Giving You Trouble?" *Iron Age*, Apr '56, p 108.
"Are Poor Bends Draining Your Stamping Profits?" *Iron Age*, May 3, '56, p 100.
"The Selection of Sheet Steel for Formability," *Metal Progress*, Aug 15, '55, p 1.

Wagner, R. A., "Designs of Stampings to Facilitate Production," *Machinery*, Feb '44, p 171.

Reprints of this Manual are available at 35¢ each until supply is exhausted. See page 142 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

Cast High-Leaded Tin Bronzes

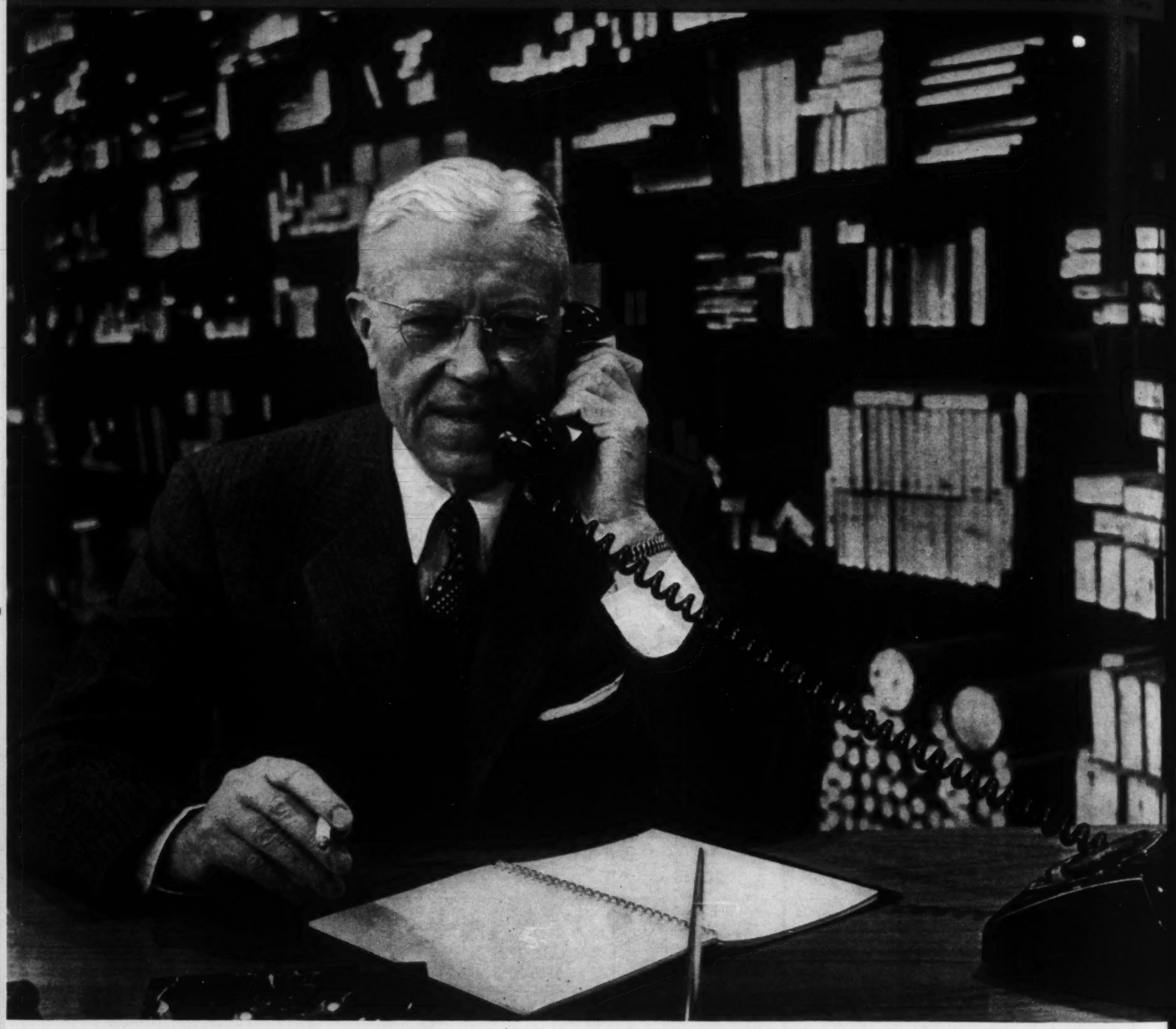
BBII Grade ➡	3A	3B	3D	3E
COMPOSITION, %	Cu 80, Sn 10, Pb 10	Cu 83, Sn 7, Pb 7, Zn 3	Cu 78, Sn 7, Pb 15	Cu 71, Sn 5, Pb 24
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.321-0.328	0.320-0.322	0.329-0.340	0.332-0.343
Melting Temp (approx), F	1770	1800	1750	1700
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	—	—	—
Coef of Ther Exp (70-400 F), per °F	10.2×10^{-6}	10×10^{-6}	10.3×10^{-6}	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension	$8.5\text{-}13 \times 10^{6}$	—	$8.8\text{-}12.6 \times 10^{6}$	$9\text{-}12 \times 10^{6}$
Ten Str, 1000 psi	27-37	30-38	25-33	23-30
Yld Str (0.5% ext), 1000 psi	15-22	17-21	14-20	11-15
Elongation (in 2 in.), %	8-12	12-20	10-18	7-16
Red. of Area, %	5-11	10-22	8-15	5-12
Hardness (Brinell)	55-70	55-65	50-60	42-35
Impact Str (Izod), ft-lb	2-8	—	4-6	4-6
Compr Yld Str (0.001-in. set), 1000 psi	12.5-16	—	13-16	12-14
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2000-2250	2000-2250	2000-2250	2000-2200
Heavy Castings	1850-2100	1900-2050	1900-2100	1850-2000
CORROSION RESISTANCE	Generally the same as for nonleaded alloys of similar composition			
USES	General purpose bushing and bearing alloy	General purpose bearing alloy, bushings, automobile fittings	Bearing bronze for moderate pressure, mine water pump parts	Bearings operating at high speed and light or medium pressure

[a]Values are given for the as-cast condition.

For more information, circle No. 515

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributors: Bethlehem Steel Export Corp.



For Answers to Tool Steel Problems

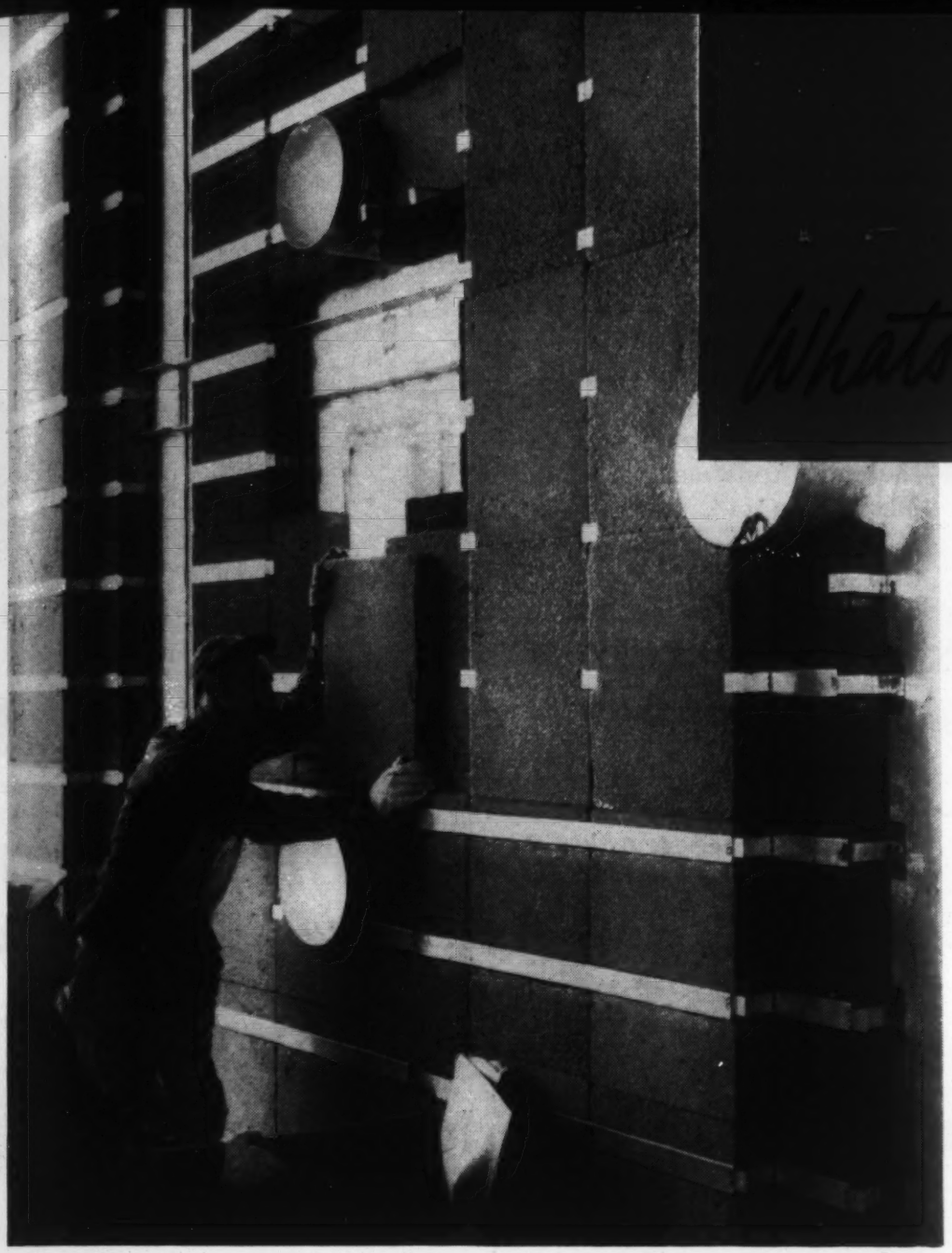
CHECK WITH YOUR BETHLEHEM DISTRIBUTOR

Virtually every business day you are faced with a question or two about tool steel. On occasion the solution is relatively easy, such as ironing out some detail about delivery. But often it can be considerably more complex—perhaps weighing the merits of two similar grades, or determining the proper cycle of heat-treatment to obtain a more effective die life.

Whatever the problem, it calls for expert opinion, and that's where your Bethlehem tool steel distributor comes in. For he's a specialist in tool steel matters, and it's part of his job to see that your questions are answered promptly and courteously. Besides, he can also save you time when you need tool steel, for his diversified stocks are ready to go at a moment's notice. Make it a point to check with your Bethlehem distributor often. It will take but a few minutes at most, and it's one of the wisest moves you can make.

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 444



Installation *of Foamsil in an aeronautical test chamber used to simulate atmospheric conditions up to 125,000 ft.*

PROPERTIES OF FOAMSIL

PHYSICAL PROPERTIES	
Density, lb/cu ft	11
Modulus of Elasticity, psi	200,000
Flexural Strength, psi	135
Compressive Strength, psi	170
Capillarity	0
Specific Gravity	0.17
Permeability	0
Hygroscopicity	No increase in weight
THERMAL PROPERTIES	
Coef of Ther Exp, per °F	3.5×10^{-7}
Combustibility	Incombustible
Ther Cond, Btu/hr/sq ft/°F/in.	
100 F	0.48
500 F	1.00
900 F	1.85
Specific Heat, Btu/lb/°F	
100 F	0.18
500 F	0.24
900 F	0.27
1200 F	0.28
Temperature Limit, F	
Cyclic	1600
Continuous	2200
Thermal Shock Resistance	Excellent

Made of pure silica foam . . .

Thermal Insulation Resists Acids

■ A ceramic insulating and refractory material has been developed which is said to be unaffected by all acids except hydrofluoric and hot phosphoric. The material, called Foamsil, is 99% pure fused silica and offers continuous insulating protection to a variety of products. It withstands thermal shock within the temperature range of -450 F to 2200 F.

Foamsil, a product of Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, is available in block sizes of 11 x 17 in. and 17 x 22 in., and in thicknesses up to 3 in. It sells for approximately 50¢ per bd ft.

Potential uses

The material has a wide range of potential uses in the chemical and chemical process industries, as well as in the metallurgical, electrical, electronic, nuclear, petroleum, petrochemical and aeronautical industries.

The silica foam is said to be ideal as a lining inside tanks and pipes that contain hot acids in any concentration. It can be used in absorbing towers, acid filters, concentrating towers, dipping vats, heat treating furnaces, electrolytic tanks, microwave absorbers, electric furnaces, pickling tanks, ceramic kilns, cupolas, incinerators, coke ovens and blast furnaces.

The fused silica foam can also be used as an underground thermal insulation, and its dielectric constant of 1.16 and loss tangent of 0.003 make it suitable as a high temperature electrical insulation.

Thermal properties

The developer says the insulating value of 1 in. of Foamsil is equivalent to that of 18 in. of acid brick at an operating temperature of 250 F. Foamsil has good thermal shock resistance and does not warp, shrink or slump during rapid temperature changes. A sample did not crack or spall after being subjected to intense heat from a steel cutting torch and then water quenched.

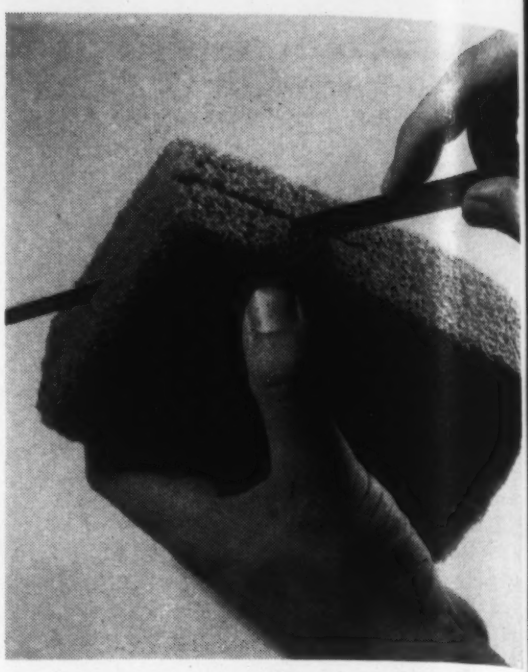
The material remains thermally

stable throughout its entire operating range because it has a low coefficient of expansion (3.5 x 10^{-7}), about 1/18 that of low carbon steel. A Foamsil block remained stable and did not deteriorate after it was heated in a furnace at 1600 F for more than two years.

Whereas most other insulations shrink at high operating temperatures, Foamsil actually expands at temperatures up to 2200 F. This feature is said to reduce the need for expansion joints and to virtually eliminate the need for joint separations to take care of expansion and contraction. (For comparative information on other thermal insulations, see M/DE, May '58, p 143, and Mar '58, p 119.)

How it's made

The insulation is made in a special horizontal furnace where pure silica, activated by a foaming agent, foams into millions of tiny, non-interconnecting bubbles. When cooled, the material becomes a lightweight rigid block with a closed cell structure.



***Cutting and shaping** of Foamsil thermal insulation can be done easily with knives and saws.*

Good heat resistance offered by . . .

Polypropylene Yarn for Rope, Fabrics, Fibers

■ Clear and colored polypropylene yarn is now commercially available from Reeves Bros., Inc., 54 Worth St., New York City. The yarn has many potential applications, including rope, wet and dry filter elements, and upholstery fabrics.

Designated Reevon Series 800, the plastics yarn is available in single-strand sizes ranging from 0.004 to 0.020 mm in dia and in multifilament sizes ranging from 0.003 to 0.008 mm in dia for each filament. Cross section of an individual strand can be round, elliptical or flat; other shapes can be made on request. The yarn can be stabilized against ultraviolet degradation.

Polypropylene rope

The yarn is presently being made into rope by Plymouth Cordage Co., Plymouth, Mass. Plymouth says polypropylene rope is significantly stronger, longer wearing, more heat resistant and less slippery than polyethylene rope. One of the rope's outstanding qualities is its high strength per unit weight. The rope is expected to find use where Dacron, nylon and polyethylene ropes are now used, e.g., barrier ropes, slings, water ski ropes, heaving lines, marine lines and electric utility lines.

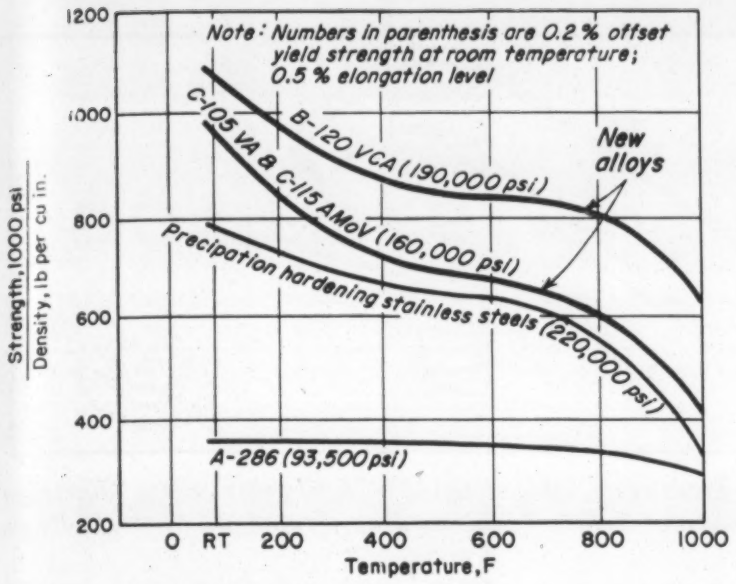
***Close-up** of polypropylene rope presently being evaluated for marine service on the tugboat "Mars" in Boston harbor.*

PROPERTIES OF POLYPROPYLENE YARN

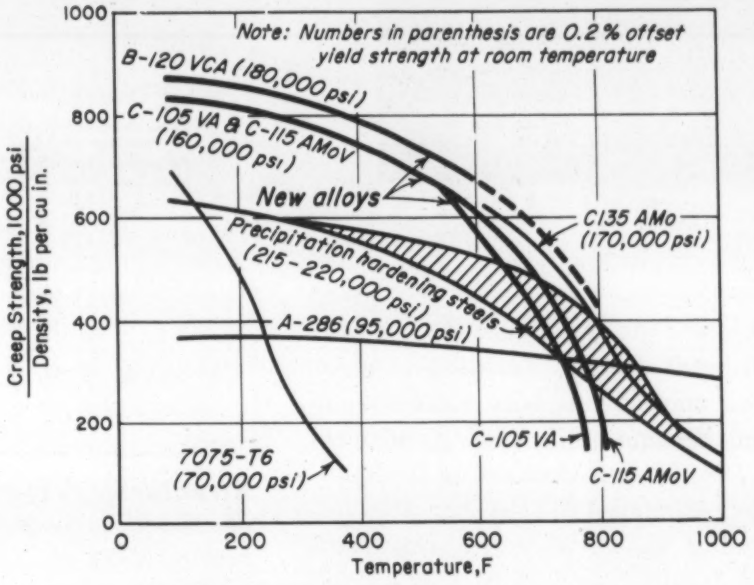
Specific Gravity	0.90
Melting Point, F	330
Softening Point (without load), F	290
Tenacity, gm/denier	6
Ultimate Elongation, %	20
Strength (as is), psi	72,000
Strength at Rupture, psi	80,000
Shrinkage, %	
165 F	6
212 F	12

Other Uses of Polypropylene

The plastic polypropylene has been finding increased use in consumer goods ever since its introduction last winter by Hercules Powder Co., Wilmington, Del. (see M/DE, Feb '58, p 155) and Montecatini Chemical Co., Milan, Italy (M/DE, Jan '58, p 110). It is presently being made into home garden sprayers, hospital ware, washing machine parts, electrical connectors, refrigerator parts, valves, pipe fittings, tumblers, tops for coffee makers, containers and furniture parts.



Yield strength-density ratio *(short time: about 2½ min) of new titanium alloys.*



Creep strength-density ratio *(500 hr) of new titanium alloys.*

First All-Beta Titanium Alloy Has Strength of 240,000 Psi

■ The use of titanium in aircraft and missiles has been given added impetus with the development by Crucible Steel Co. of three new high strength titanium alloys.

One of the alloys, believed to be the first all-beta titanium alloy ever produced, is said to possess the highest strength (it can be heat treated to a tensile strength of 240,000 psi) and best formability of any titanium-base material. The other two, presently available in the form of sheet, are capable of being solution treated to a soft, easily formed condition and then aged to high room and elevated temperature strength levels.

According to Crucible, the three alloys represent a substantial advance in the direction of high strength, formable titanium alloys.

Beta alloy

Composition and structure—According to Crucible, the new beta alloy is the most significant titanium development thus far. Titanium, like iron, has both low and high temperature crystal structures; the high temperature structure of titanium, corresponding to austenite in iron, is called beta.

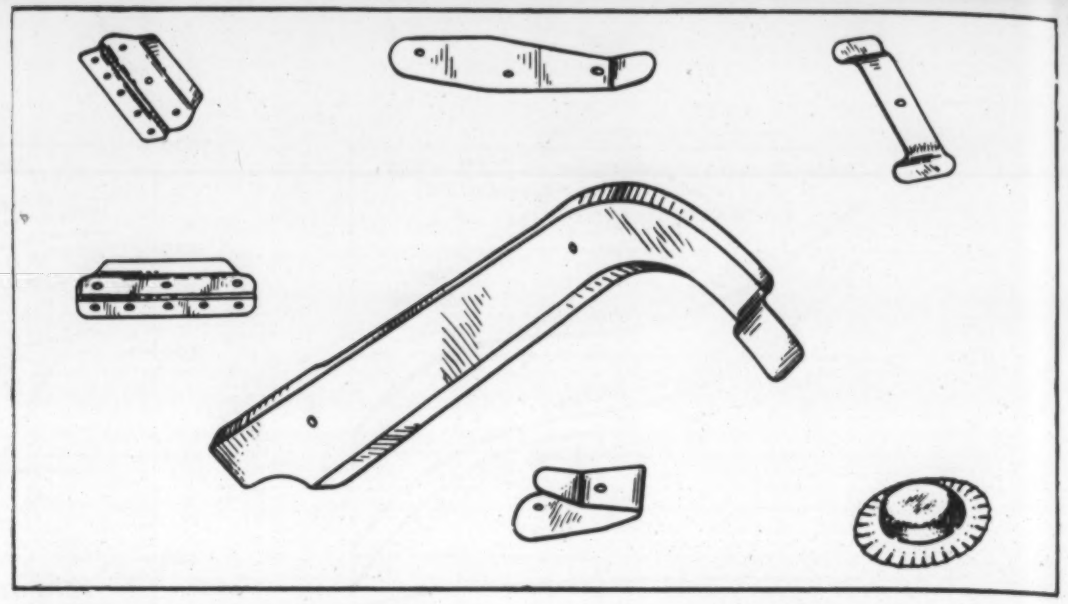
The basis for the development of the beta alloy (B-120VCA) was the "need to stabilize titanium's high temperature beta structure down to room temperature in order to secure the advantages of titanium's excellent formability." This aim led to the addition of a relatively large amount of alloy beta stabilizer elements: 13 vanadium and 11% chromium. Aluminum (4%) was also added to

MECHANICAL PROPERTIES OF THREE NEW TITANIUM ALLOYS

Alloy ↓	Form	Condition	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (2 in.), %	Red. of Area, %
B-120VCA	Sheet	Solution Treated/ Annealed	140	135	15	40
		Aged	190	170	6	—
			200	180	5	—
			210	190	4	—
			220	200	3	—
			240	220	2	—
C-115AMoV	Sheet	Solution Treated	140	90	16	—
		Aged	190	168	8	—
C-105VA	Sheet	Solution Treated	110	55	18	36
		Aged	180	165	5.5	17
	Bar	Solution Treated	105	30	16	30
		Aged	190	182	5	17

ELEVATED TEMPERATURE PROPERTIES OF THREE TITANIUM ALLOYS

Alloy ↓	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong, %
B-120VCA			
Room Temp.	204	190	5
200 F	190	170	6
400 F	180	150	8
600 F	175	145	9
800 F	153	140	9
1000 F	115	100	10
C-115AMoV			
Room Temp.	180	165	7
400 F	145	110	7
600 F	135	100	7
800 F	120	95	9
1000 F	98	84	15
C-105VA			
Room Temp.	180	165	5.5
400 F	150	145	5.5
600 F	140	130	6
800 F	125	110	6



Structural airframe members *made of B-120VCA titanium alloy. (Sketches are based on actual parts presently being used by Grumman Aircraft Engineering Corp.)*

assure that the structure remains all-beta during forming and/or slow cooling but does not over-age and become embrittled in service.

Properties—According to Crucible, Alloy B-120VCA has the following advantages: 1) excellent bendability and formability; 2) excellent weldability; 3) the ability to be heat treated to high strength levels with no special equipment; 4) aging characteristics that are not markedly affected by forming after solution treatment; 5) non-directionality of properties; 6) good flatness in sheet form; 7) low scratch sensitivity; 8) no evidence of stress cracking or delayed cracking; 9) high tolerance to hydrogen; 10) ability to be brazed; and 11) ability to be coldheaded.

Other properties are given in the two graphs which show, respectively, short-time yield strength-density ratios and long-time creep strength-density ratios of the new beta alloy as compared to several other high strength alloys. As shown, the short time (about 2½ min) strength-density ratio of B-120VCA is considerably better than that of any of the others up to at least 1000 F. For a considerably longer time (500 hr), the new alloy has a strength-density advantage up to at least 600 F and probably as high as 800 F. Beyond this time-temperature combination, the new alloy becomes stronger but less ductile, and some of the other alloys are more suitable.

Heat treatment—The beta alloy is made formable by solution treating 15-30 min at 1400 F, followed by an air cool. To age harden, the alloy is held 50-100 hr at 850-900 F. Double-step aging sequences presently being developed promise to lower the total aging time to about 10-20 hr.

Applications—Alloy B-120VCA is currently being tested in aircraft for such things as skins, stiffeners and other primary structural shapes requiring high strength for long times at temperatures up to at least 575 F. Preliminary tests indicate that B-120VCA has no equal as a material for honeycomb construction. And the alloy appears to be ideally suited for missile applications such as pressure tanks, casing skins and structural members requiring excellent strength-weight ratios for a few hours up to 1000 F and for shorter times up to 1400 F. The alloy also has a large potential for rivets and bolts in aircraft and missiles.

C-115AMoV

Composition and properties—Crucible's second new titanium alloy (3 molybdenum, 1 vanadium and 4% aluminum) offers good formability in the solution treated condition; improved strength properties, both at room and elevated temperatures in the aged condition; and elevated temperature stability in the aged condition to at least 800 F.

According to Crucible, this alloy offers the following advantages: 1) adequate bendability; 2) high strength with useful ductility; 3) excellent creep resistance under moderate stresses up to 800 F; and 4) good time-temperature-stress stability. Its limitations are poor weldability and poor formability as compared to B-120VCA and C-105VA.

Heat treatment—The solution temperature can be varied from 1500 to 1675 F, depending upon the properties desired in the solution treated and/or aged condition. The recommended solution treatment to produce parts capable

MORE WHAT'S NEW IN MATERIALS

Rubber, plastics parts cured faster 136
500 F aluminum alloy 140
Seven new adhesives 140
Shock resistant steel 144
Synthetic sapphires 144
Polyethylenes in wide density range 146
Aluminum-iron strip 148
Porcelain-to-aluminum seal 148
Bearing material of bronze, lead, TFE 150
Gas turbine lubricants 152
Improved epoxy resins ... 154
Intermetallic becomes magnetic when cold 156
Carbon-corrected bars 158
Uniform plastics parts 158
Plasma jet applies metallic coatings 162
Sealing tape for glass 164
Ceramic-coated wires 164
Silver-striped brass 166
Ceramic parts resist rapid heat changes 166
Alkyd moldings 168
Other news 170

For more information, circle No. 498 ➤

now

complete your Riehle testing machine reference file...

You can take the first step toward solving your materials problems by bringing your Riehle testing machines catalog file up to date. Check the list below, clip it to your letterhead, and we'll send the catalogs you request promptly, without obligation.

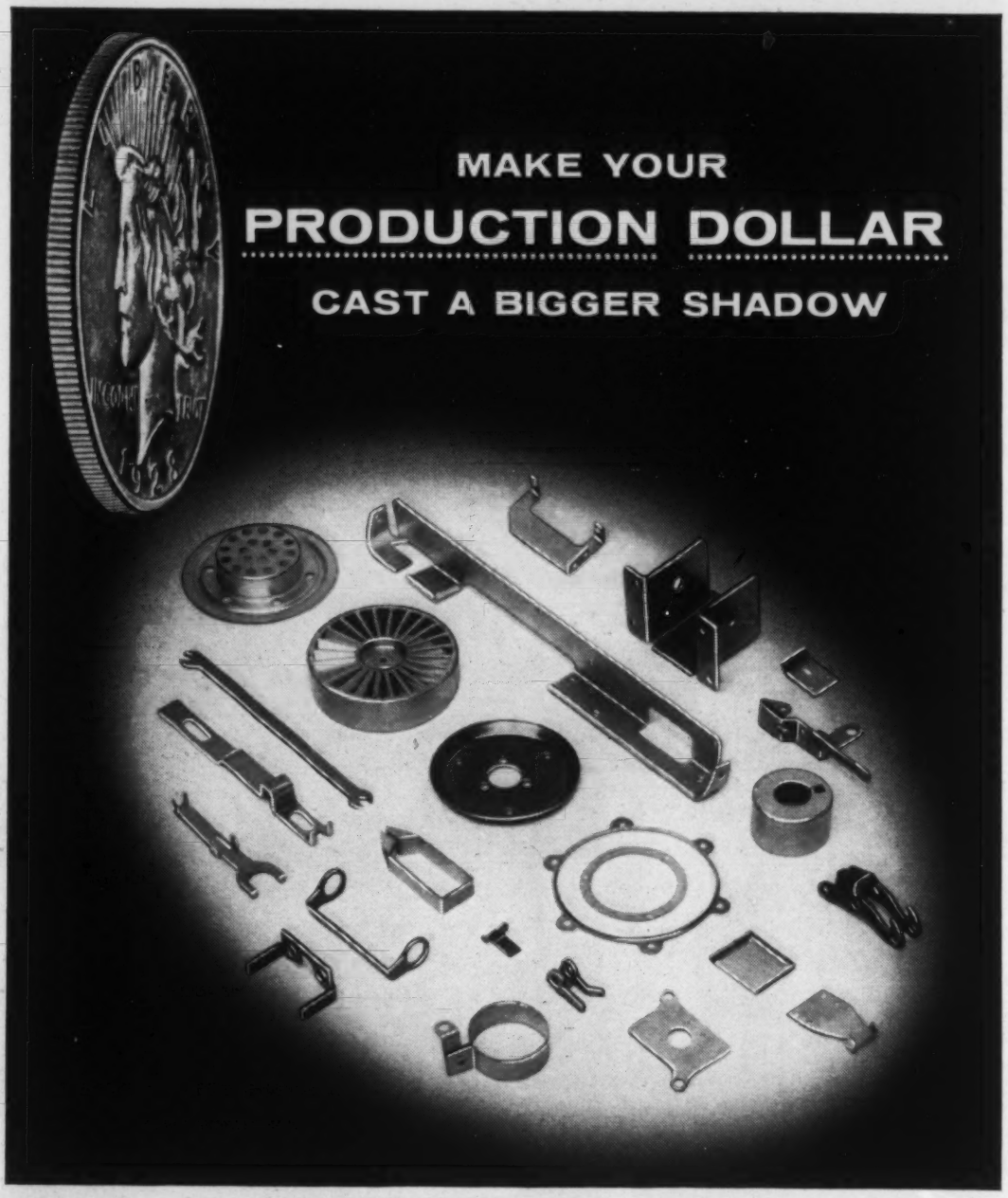
- ☐ Universal Hydraulic Testing Machines and Accessories
- ☐ Universal Screw Power Testing Machines and Accessories
- ☐ Construction Materials Testing Machines and Accessories
- ☐ Torsion Testing Machines
- ☐ Creep and Stress-Rupture Testing Machines
- ☐ Losenhausen Fatigue Testing Machines
- ☐ Brinell Hardness Testers
- ☐ Vickers Hardness Testers
- ☐ Portable Hardness Testers
- ☐ Cable and Wire Testers
- ☐ Horizontal Tensile Testing Machines
- ☐ Impact Testing Machines
- ☐ Testing Machines Guide
- ☐ Riehle Recorder and Accessories
- ☐ Riehle Electro-Balanced Indicator Unit

Riehle **TESTING MACHINES**

A DIVISION OF

American Machine and Metals, Inc

EAST MOLINE, ILLINOIS

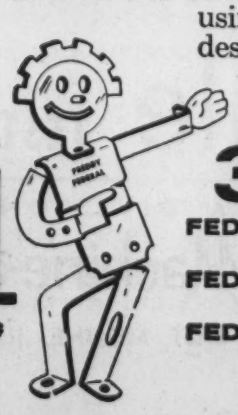


Federal Short Run Stampings may be your answer

Stretch your production tooling dollar up to 80% by using Federal "Controlled Tolerance" Short Run Stampings. That's the savings you get by using the Federal Stamping method instead of conventional tooling methods. You can *put a new product* on the market or make improvements in *existing products* with a *minimum tooling investment*. When quality, fast delivery and price are important factors, try Federal first for any quantity stampings from two pieces to 10,000. Size limitations are 10" x 14" and 3/8" in thickness. Send your print or part to the nearest plant for a Federal Analyzed Quotation.

Write for free Catalog 201. Tells how to reduce costs by using short run stampings . . . full of design tips.

QUALITY STAMPINGS
FEDERAL
IN SMALL QUANTITIES



3 PLANT LOCATIONS

FEDERAL TOOL & MANUFACTURING CO.
3652 Alabama Ave., Minneapolis 16, Minn.

FEDERAL SHORT RUN STAMPING, INC.
962 Lyell Avenue, Rochester 6, N.Y.

FEDERAL STAMPING COMPANY
7307 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service card, circle No. 506

What's new IN MATERIALS

of being aged to the 170-190,000 psi range with 5-10% ductility is heating at 1625 F ± 15 F, followed by a water quench. The aging cycle can also be varied over a wide range of temperatures and times, depending upon the desired combination of aged strength and ductility. Recommended aging cycle to meet the 170-190,000 psi range with 5-10% elongation is 12 hr at 925 F. Longer times and/or higher temperatures will give lower strength-higher ductility; shorter times and lower aging temperatures will give higher strength-lower ductility.

Applications—This sheet alloy has shown considerable promise for aircraft applications requiring heat treated strength of 170,000 psi with about 6-10% elongation.

C-105VA

Composition and properties—The third new alloy, an alpha-beta type with a nominal alloy content of 16 vanadium and 2.5% aluminum, was designed to satisfy two conflicting aircraft requirements for sheet materials: 1) it must be soft, ductile and easily formed; and 2) it must possess high strength at temperatures as high as 800 F.

According to Crucible, the first requirement can be met by furnishing the sheet material in the solution quenched condition. The second requirement can be met by subsequently aging the formed parts at moderately elevated temperatures (see below).

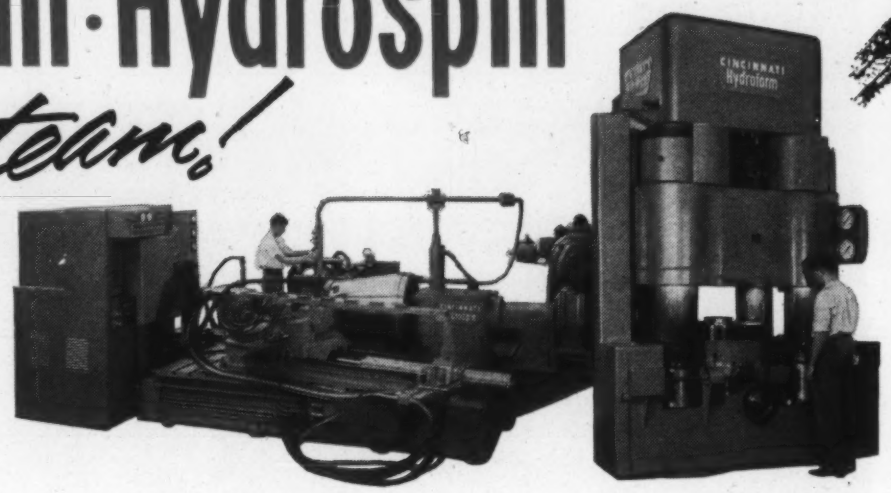
Other advantages listed for this alloy are excellent formability and weldability. Limitations: relatively low aged ductility, and relatively high creep rate at 800 F in the aged condition.

Heat treatment—Heat treatment is accomplished by controlling stability and transformation of the beta phase by a suitable heating, quenching and aging schedule. A wide range of strength-ductility combinations is available by varying temperatures and times. Solution temperatures can be varied from 1250 to 1450 F. Quenching media can vary from air to brine, depending on section size and temperature; however, a water quench is most frequently used.

Applications—The principal use to date for this alloy is in sheet

HOW TO SAVE TIME AND MONEY IN MISSILE METALWORKING:

Employ a Cincinnati Hydroform·Hydrospin *team!*



Shown at left are three quick steps of producing a guided missile component employing a Cincinnati Hydroform-Hydrospin winning team.

Using low-cost tooling, the preform (Fig. 1) was produced in one draw, without thinout, from a 23″ diam. blank of 6061 Aluminum on a Cincinnati 32″ Hydroform. Size of preform is 12″ major diam. x 13″ deep x ⅛″ wall thickness.

After heat treating, the preform was "*chipless machined*" on a Cincinnati Hydrospin. The first spinning (Fig. 2) roll-flowed the preform to 20″ length x 12″ major diam. x 0.080″ wall thickness. Floor-to-floor time; 3½ minutes. The final spinning (Fig. 3) increased part length to 40″ and reduced wall thickness to 0.040″ ± 0.005″. Floor-to-floor time; 4¼ minutes. The alloy of the finished part is in the T6 condition.

You'll save costs and speed missile parts production with Cincinnati® Hydroform® and Hydrospin® machines. Call in a Meta-Dynamics Division field engineer for full details.

Hydroform/Hydrospin

META-DYNAMICS DIVISION

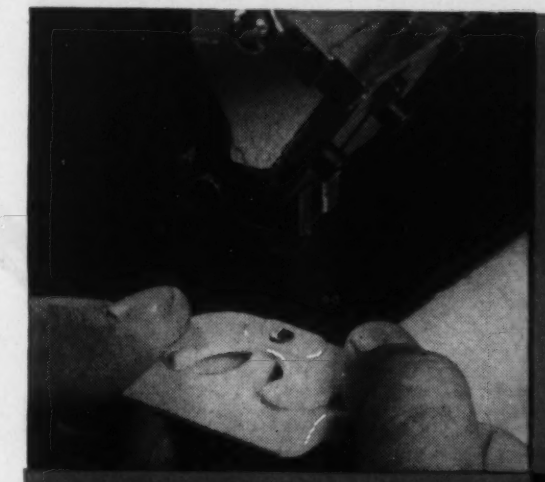
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

For more information, turn to Reader Service card, circle No. 401

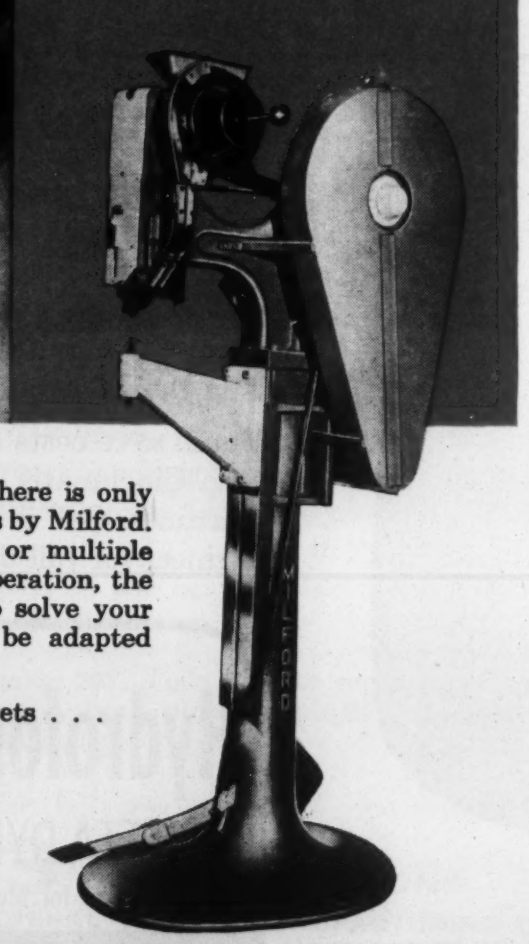
HERE'S HOW A MILFORD RIVETER CUTS PRODUCTION COSTS, SPEEDS ASSEMBLY AUTOMATICALLY!



The operator places the parts over the roll set plunger. A tubular rivet has dropped from the feed rails into the jaws.

As the operator trips the machine to begin the cycle, the jaws and driver automatically carry the rivet down to the work.

The rivet contacts the roll set plunger. The spring-loaded plunger recedes, guiding the rivet through the assembly where it is clinched on the underside.



The floor-mounted Riveter shown here is only one of a full line of automatic riveters by Milford. Bench or floor models . . . single or multiple spindle . . . manual or automatic operation, the Milford Riveter line is designed to solve your toughest assembly problems, can be adapted to your particular operation.

For a complete line of tubular rivets . . . for fast, trouble-free assembly . . . look to Milford!

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

For more information, turn to Reader Service card, circle No. 417

What's new IN MATERIALS

parts requiring excellent formability and high aged strength. Preliminary tests with plate, bar and billet (now in pilot-scale production) indicate considerable promise for these forms in aircraft and missile uses.

Rubber, Plastics Parts Cured Faster with Aids

Rubber and plastics parts can now be cured faster and more effectively than before by using a series of latent curing aids called Chemical-Loaded Molecular Sieves. Molecular Sieves are man-made crystalline alumino-silicate materials chemically similar to many natural clays, and belong to a class of minerals known as zeolites.

The Chemical-Loaded Sieves, developed by Linde Co., Div. of Union Carbide Corp., will be sold by Harwick Standard Chemical Co., Akron, Ohio at an initial price of $3 per lb.

Typical uses

Linde says the loaded Sieves permit the use of rubber and plastics vulcanization agents previously considered too active or volatile for practical use. For instance, catechol is a very powerful curing aid for neoprene, but neoprene compounds containing it have such a short Mooney scorch time (3.5 min) at 250 F (see Fig 1) that processing is almost impossible. As indicated on the graph, a catechol-loaded Sieve increases Mooney scorch time at 250 F by 28 min and permits safe processing of the neoprene compound.

In addition to neoprene, the loaded Molecular Sieves can be used in styrene-butadiene (SBR), natural (NR), nitrile (NBR) and silicone rubber; epoxy resins; and rigid vinyl plastisols. The curing aids are currently being evaluated in such rubber items as tires, mechanical goods, hose, belting and footwear.

According to Linde, high concentrations of Chemical-Loaded Molecular Sieves can be used to obtain rapid cures without seriously affecting processing safety. Fig 2 shows that increasing the concentration of a piperidine-loaded Sieve from 0.6 parts per hundred to 1.8 parts per hundred in a styrene-butadiene

FOR 50 YEARS

the time-tested world standard
in resistance alloys

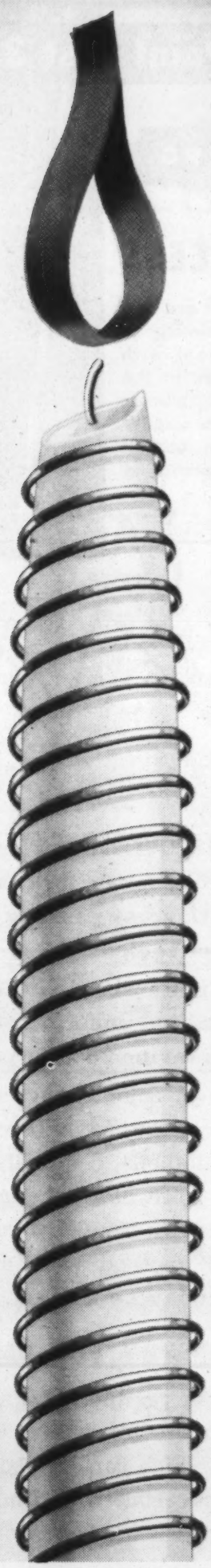
Nichrome*

made only by Driver-Harris

On August 11, 1908, the trademark NICHROME for Resistance Wire was registered in the United States Patent Office.

Today, after a half century of world wide recognition and use, Nichrome is still the accepted standard of quality in electrical resistance alloys.

Of the 132 special purpose alloys now produced by Driver-Harris for the Electrical, Electronic and Heat Treating Industries, Nichrome is the most famous . . . and it is made only by Driver-Harris.



* T.M. Registered U.S. Pat. Office

DRIVER-HARRIS* COMPANY

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

SPECIAL PURPOSE ALLOYS SINCE 1890 — D/H — TRADE MARK REG. U.S. PAT. OFF.

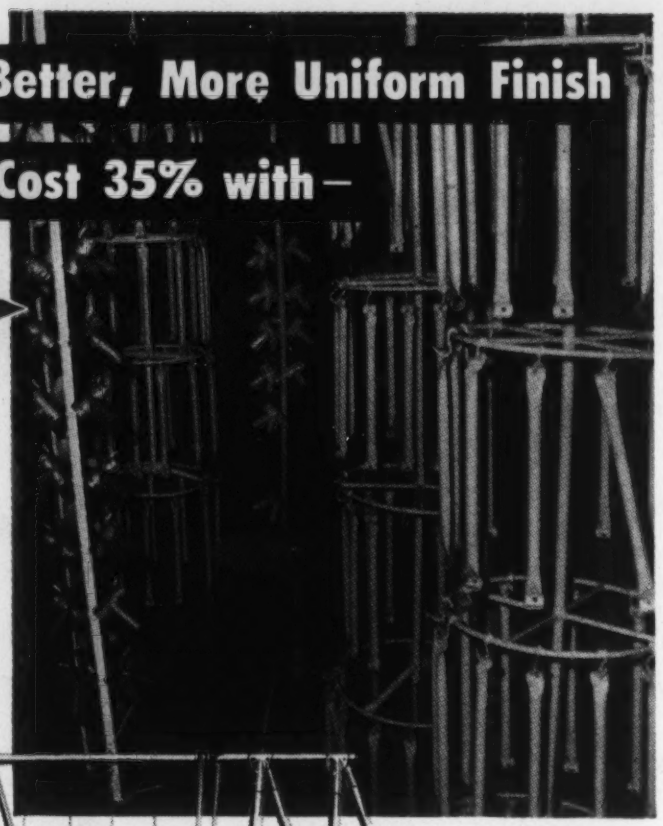
For more information, turn to Reader Service card, circle No. 504

TURCO Gets a Better, More Uniform Finish And Cuts Paint Cost 35% with—

RANSBURG

NO. 2 PROCESS

Frequent color changes are simplified now in the painting of playground equipment with Ransburg Electro-Spray in this St. Louis plant. Long, tubular parts, as well as these smaller pieces, are uniformly coated with the Ransburg reciprocating disk.



QUALITY IMPROVEMENT! That was Turco Manufacturing's chief reason for changing from flo-coat to electrostatic spray painting of their quality line of playground equipment.

Not only is Ransburg No. 2 Process providing a higher quality, uniform coating on all parts, but Turco is saving 35% in paint cost!

Simplicity in color change with Electro-Spray is another important advantage here. With Turco's production methods, colors are changed 15 times in an 8-hour shift. Now, changes are made on the fly with no down-time. By contrast, the former "stop and go" method would mean over an hour's lost time in a day's operation.

NO REASON WHY YOU CAN'T DO IT TOO!

Whatever your product, if it's painted, we'd like to tell you more about the worthwhile savings and benefits which can be yours with RANSBURG ELECTROSTATIC PAINTING PROCESSES. Write for our No. 2 Process brochure which cites many examples of electrostatic spray painting on a wide variety of products.

Call or write

RANSBURG
Electro-Coating Corp.
P. O. Box 7822, Indianapolis 23, Ind.

For more information, turn to Reader Service card, circle No. 378

What's new IN MATERIALS

(SBR) compound has essentially no effect on Mooney scorch time at 250 F.

How they work

The curing aids, a combination of catalysts and crosslinking agents "locked" within the pore structure of the Molecular Sieve, are effectively isolated from the rubber or plastics compound during storage and processing. However, at curing temperatures the active compound in the Sieve is released almost 100% into the curing system and speeds up the rate of cure without sacrificing processing safety or pot life.

Five types available

At present, five types are available in commercial quantities:

CW-1015, piperidine-loaded and used as a secondary accelerator with

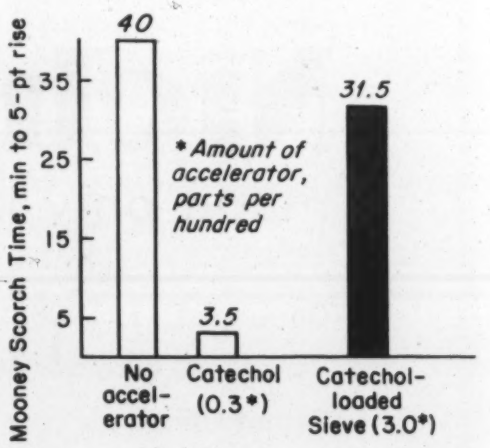


***Fig 1**—Catechol-loaded Sieve gives better Mooney scorch time for a neoprene compound than catechol-accelerated and non-accelerated compounds.*

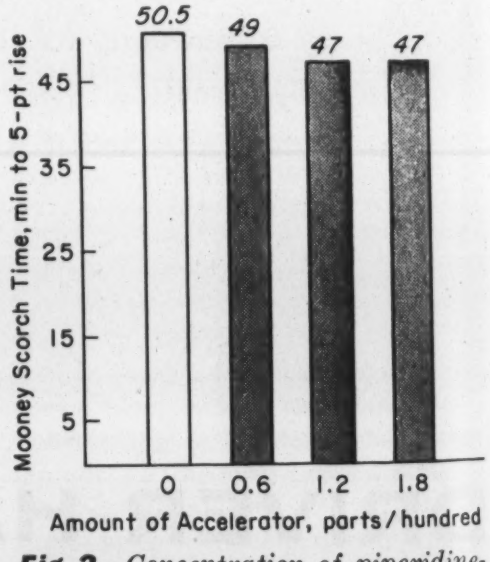


***Fig 2**—Concentration of piperidine-loaded Sieve can be increased without affecting processing safety of compound.*

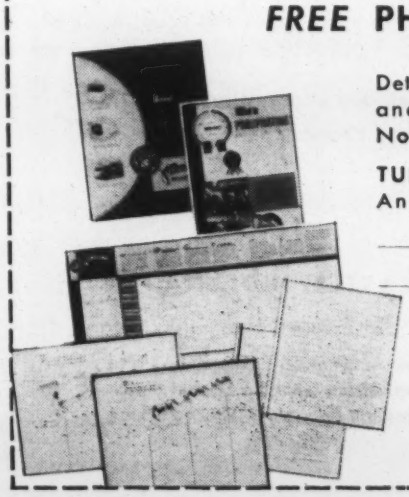
Phosphating processes now available…to fit any production or cost requirement!

New Turcoat concept puts better paint adhesion within the reach of everyone!

In the past, phosphating processes—due to their high initial costs—have principally been utilized only by the larger plants. Realizing the need for better paint adhesion and corrosion resistance among many plants who have not previously utilized phosphating, Turco has broadened its Turcoat line and now offers—for the first time—phosphating processes that can be tailored to fit your individual *production* and *cost* requirements. Turcoat processes currently in use range from small, inexpensive 3-tank set-ups all the way to elaborate 11-stage spray washing systems. With Turcoat, paint is anchored uniformly… permanently. Should accidental gouging occur, there is no corrosion "creep-back" under the paint. Turcoat systems quickly pay for themselves by slashing number of rejects and other problems involved in improper preparation, by minimizing packing and crating costs, by establishing and assuring customer preference.

TURCO PRODUCTS, INC.
Chemical Processing Compounds
6135 So. Central Ave., Los Angeles 1, Calif.
Offices in all Principal Cities
Mfg. in Canada by B. W. Deane & Co., Montreal

FREE PHOSPHATING ANALYSIS KIT!



Determine how *your* products are adaptable to phosphating and to the many paint adhesion advantages it offers. No obligation.

TURCO PRODUCTS, INC., 6135 So. Central Ave., Los Angeles 1, Calif.

_____ Please send free Phosphating Analysis Kit

_____ Please send field engineer for on-the-job survey

Name _____ Title _____

Firm _____

Address _____

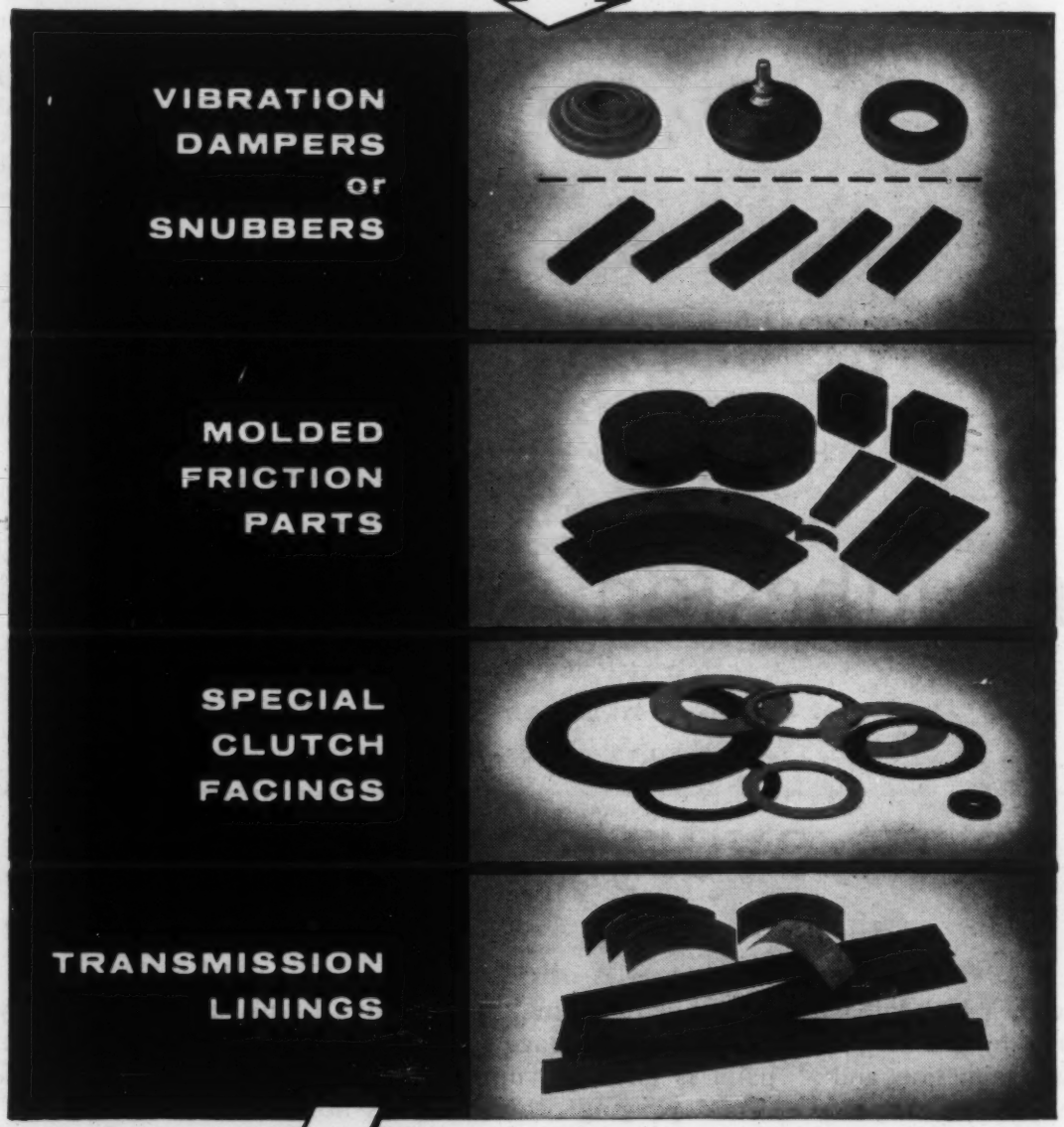
MDE

For more information, turn to Reader Service card, circle No. 437

let **WORLD BESTOS**

help you

in the design and production of



● World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

● Send your blueprints (or samples) for prices and delivery information to WORLD BESTOS, Industrial Products Section, New Castle, Ind., Phone: 2360. Write for free illustrated folder.

WORLD BESTOS NEW CASTLE, INDIANA

DIVISION OF THE Firestone TIRE & RUBBER COMPANY

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

For more information, turn to Reader Service card, circle No. 362

What's new IN MATERIALS

thiazole primary accelerator.

CW-1115, di-n-butylamine-loaded and used as a secondary accelerator with thiazole primary accelerator.

CW-3010, catechol-loaded and used as a neoprene accelerator.

CW-3120, diethyl thiourea-loaded and used as a neoprene accelerator.

CW-2015, di-tertiary butyl peroxide-loaded and used as a non-sulfur curing agent for vinyl-containing silicon rubber compounds.

Aluminum Alloy Withstands 500 F

A heat resitant aluminum alloy, developed in England and sold there under the name RR 58, is now available in this country from Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11. Designated alloy 2618, the material is recommended for use at temperatures up to 500 F.

Alloy 2618 in the T61 temper has an ultimate tensile strength of 64,000 psi and a yield strength of 54,000 psi. The alloy retains an ultimate strength of 50,000 psi and a yield strength of 45,000 psi after aging 10,000 hr at 300 F.

Kaiser is supplying the alloy in sheet, plate, extrusions, and hand die forgings.

Seven New Adhesives Bond Plastics, Metals

Seven new adhesives have been introduced recently. Three of them are designed to cut production costs in the manufacture of honeycomb sandwich constructions; the other four are designed for bonding a variety of plastics films to themselves and to other materials.

1. Adhesives for honeycomb

AF-200, -201—Minnesota Mining & Mfg. Co., Adhesives and Coatings Div., 411 Piquette Ave., Detroit 2, has introduced two new, heat curing, supported, composite film adhesives for honeycomb sandwich constructions. Designated as Scotch-Weld B[illegible]ng Films AF-200 and AF-201, the adhesives consist of a high

"WEIRZIN'S® ZINC-COATED SURFACE DEFIES CORROSION—TAKES PAINT BEAUTIFULLY!"

REPORTS LINCOLN METAL PRODUCTS CORPORATION, MAKERS OF BEAUTYWARE

A leading manufacturer of such housewares as kitchen canister sets, bread boxes, step-on cans and towel dispensers, Lincoln Metal Products of Brooklyn, N. Y., finds Weirzin electrolytic zinc-coated steel a natural for its purposes.

"Inventory problems are simply non-existent," says a spokesman. "You can store stamped-out parts of Weirzin indefinitely—even for years without worrying." Because its electrolytically fused zinc coating is so tight, not even the severest bending, drawing or crimping operation will flake or peel off its surface during fabrication. No exposed steel—no corrosion problem!

Also you'll discover—as have Lincoln Metal Products and many other users—that appearance is not the only beauty of chemically treated Weirzin's paintability: the economy of that lasting paint job is one of its biggest drawing cards, too.

In the market for a metal that combines strength, economy and super-resistance to corrosion? You'll find it eminently worth your while to investigate Weirzin.

Free Booklet "Weirzin" Gives Complete Details. Write to Weirton Steel Company, Dept. E-19, Weirton, West Virginia

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 427

Available Now!!

Reprints of

MATERIALS IN DESIGN ENGINEERING MANUALS

Because of the great demand for the well-known Manuals that are widely used for reference purposes, MATERIALS IN DESIGN ENGINEERING Manuals have been reprinted for your use. These outstanding 16- to 32-page articles provide you with complete and useful information on the properties, characteristics and uses of engineering materials and finishes.

The price is right! Only 35¢ for each reprint. On quantity orders, discounts are offered. To obtain your copies, indicate in the handy coupon below the Manuals you want. Orders will be filled as long as the supply lasts.

Would you prefer receiving these valuable Manual reprints automatically each month in the future? If you are a subscriber to MATERIALS IN DESIGN ENGINEERING, then avail yourself of an additional service offered by our Reader Service Department. Let us add your name to our mailing list, and you will receive the next 12 Manual reprints, one each month, for the reasonable price of $4.00* per year. Just fill out the coupon below and mail it to:

Reader Service Department
MATERIALS IN DESIGN ENGINEERING
430 Park Avenue
New York 22, New York

Quantity		Quantity	
....	Carbon and Low Alloy Steel Castings	....	How to Select and Specify Glass
....	Malleable Iron Castings	....	Nickel Silvers
....	Welding the Stainless Steels	....	Hard Coatings and Surfaces
....	Wood & Wood-Base Materials	....	Selecting Plastics Laminates
....	Engineering Coppers	....	Hot Forged Parts
....	Clad and Precoated Metals	....	Solid Electrical Insulation Materials
....	Wrought Non-Leaded Brasses	....	Fluorocarbon Plastics
....	Silicones—Properties & Uses	....	Magnesium and Its Alloys
....	Short Run Press Formed Parts	....	Conversion Coatings for Metals
....	Finishes for Plastics	....	Synthetic Rubbers
....	How to Select a Wrought Steel	....	Titanium
....	Impact Extruded Parts	....	Materials for Gears
....	Finishes for Metal Products	....	Mechanical Tubing
....	Nodular or Ductile Cast Irons	....	Joining & Fastening Plastics
....	Industrial Textile Fibers	....	Aluminum Alloy Castings
....	Pressure Sensitive Tapes	....	Thermal Insulation Materials
....	New Stainless Steels	....	New Developments in Ceramics
....	Foam Plastics	....	Designing with Heat Treated Steels
....	Electroplated Coatings	....	Porcelain Enamels, Ceramic Coatings
....	Materials for Electrical Contacts	....	Paper as an Engineering Material
....	Gray Iron Castings	....	Designing Metal Stampings

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

☐ Yes, I am a subscriber to MATERIALS IN DESIGN ENGINEERING and would like to be put on your mailing list to receive each future Manual, when reprinted. Please start with the .....issue. Upon receipt of your invoice, I will pay $4.00 for a year's supply. * Foreign subscriptions—$4.80.

strength elastomeric adhesive film on one surface and a self-filleting adhesive film on the other. The elastomeric adhesive bonds to the facing and the self-filleting adhesive bonds to the core of the honeycomb sandwich panel. According to 3M, the adhesive films reduce production costs for high strength sandwich panel constructions, and have high peel and beam shear strengths at temperatures from —70 to 250 F.

In recent field evaluations, composite adhesive film AF-200 has joined aluminum honeycomb sandwich panels with a beam shear strength of 1580 psi at —67 F and 1385 psi at 180 F. Panel failures were caused by core delamination and not by adhesive bond failure.

Plymaster V-3—The other adhesive designed for honeycomb sandwich constructions is called Plymaster V-3. Described by the manufacturer, Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J., as a "low cost, 4-mil thick, 100% reactive synthetic rubber-phenolic resin film adhesive," Plymaster V-3 is designed especially for bonding flat metal sheets and flexible plastics films to rigid and semi-rigid metals and plastics. The solvent-free film adhesive is also capable of bonding wood composition board, leather and fabrics.

2. Adhesives for plastics films

Three adhesives for laminating Mylar and treated polyethylene films to themselves, to vinyl and Saran films, and to paper, have been developed by National Starch Products Inc., Adhesives Div., 270 Madison Ave., New York 16.

Resyn 30-1246 is a clear, synthetic resin adhesive used to laminate metallized Mylar film to calendered vinyl film.

Resyn 36-6327 is a synthetic rubber adhesive used to laminate treated polyethylene film to clear Mylar and to Saran coated films. In addition, it may be used to laminate clear and metallized Mylar film to nitrocellulose and to vinyl coated paper.

Resyn 36-6328 is a synthetic rubber lacquer used to laminate clear and metallized Mylar film to itself and to paper.

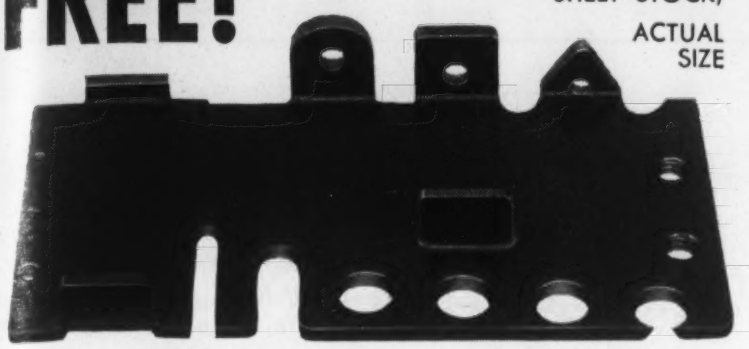
In addition, Adhesives Products Corp., 1660 Boone Ave., New York 60, has developed *Cellugrip*, a sol-

For more information, turn to Reader Service card, circle No. 363

FREE!

(SAE 1010-3/32" CRS—SHEET STOCK)

ACTUAL SIZE



Short-Run Design Suggestion Sample

ENGINEERS responsible for the design function will welcome this practical short-run stamping sample which *visibly* shows various common conditions that occur in metal fabrication.

An actual production sample, it indicates typical mechanical problems met with in terms of type of material, temper and thickness.

REQUEST SAMPLE AND BULLETIN DSS-2 ON YOUR LETTERHEAD

DAYTON ROGERS
Manufacturing Company
MINNEAPOLIS 7X, MINNESOTA

FOR DEPENDABLE QUALITY
SPECIFY
Cellusuede
FLOCK

Dampens Vibration... Silences Noises...

ADDS BEAUTY, COLOR, SALES APPEAL

Every year more and more product designers find profitable uses for Cellusuede Flock. The fascinating textures of this versatile finish add new vitality, color, and sales appeal to many products. Or, Cellusuede takes on more enduring — even rugged textures for such varied functions as providing a protective cushion, dampening vibration, and silencing noises. Less expensive than fabric, Cellusuede is made principally from cotton, rayon, or hair fibers, and is available in an almost limitless combination of textures and colors to meet your needs.

Free Bulletin, Technical Assistance

Call on Cellusuede for help with any potential application. Unexcelled facilities are available for flocking test samples. Ask for free bulletin describing profitable uses.

A DURABLE PROTECTIVE COATING WITH A THOUSAND USES . . .

- Can be applied to any surface which will support an adhesive film.
- Easy to apply on an individual or production-line basis — by spray, vibration, or electrostatic process.
- Wide range of textures and colors to suit your needs.

CELLUSUEDE PRODUCTS, INC.
511 N. MADISON STREET, ROCKFORD, ILLINOIS

For more information, turn to Reader Service card, circle No. 428

Your key to quality in

PLASTIC MOLDING

MACK is one of the original plastic molders . . . offers industry-wide experience in design, mold making and choice of materials. High efficiency production methods and finishing assure economical, quality production. MACK engineers are available for consultation. They will recommend the best design for your product and the most efficient method of producing it. Estimates on your requirements will be made without obligation.

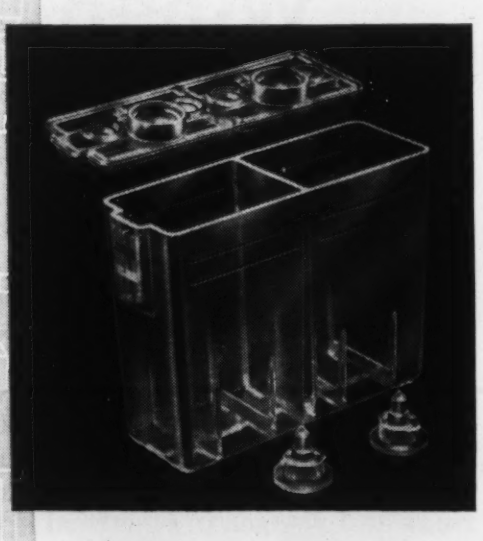
38 YEARS OF CUSTOM MOLDING TO INDUSTRY

Consult Mack engineers for assistance in solving your plastic molding problems —

- **DESIGN ASSISTANCE**
- **MATERIALS SELECTION**
- **MODERN PRODUCTION METHODS**
- **MASTER TOOL MAKERS**
- **RIGID QUALITY CONTROLS**

— complete custom service by

MACK MOLDING

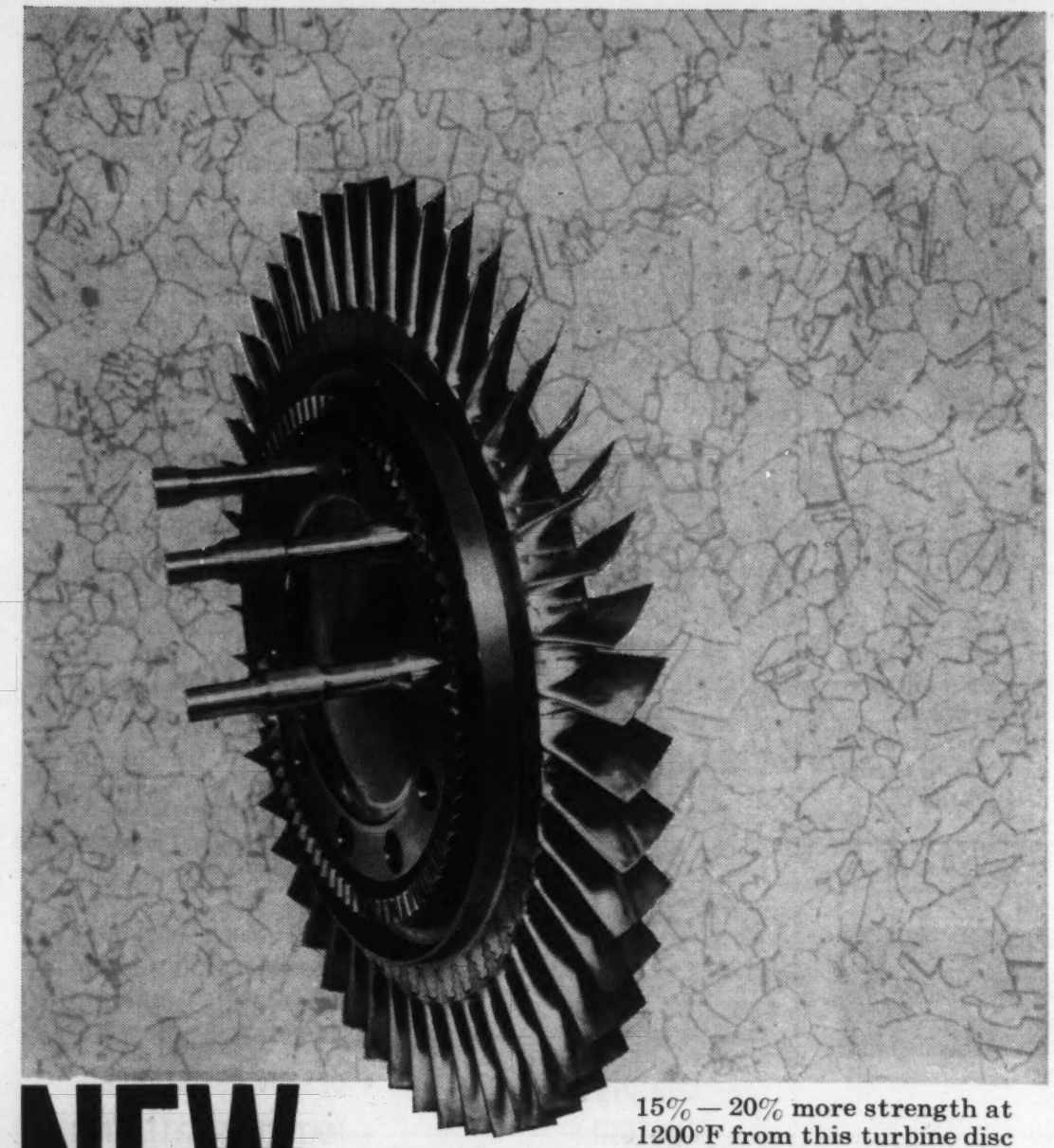


One of the many rugged battery cases molded by MACK

MACK
MOLDING CO • INC
General Offices and Main Plant:
WAYNE • NEW JERSEY

Other Plants located in
ARLINGTON, VERMONT and
WATERLOO, QUEBEC, CANADA

For more information, turn to Reader Service card, circle No. 439



15% — 20% more strength at 1200°F from this turbine disc gives added dependability.

NEW 2 high temperature alloys from Westinghouse W-545 . . .Nicrotung

W-545 is an improved high-strength and high-temperature material with low strategic alloy content for ease of fabrication. Critical high-temperature parts can be made from this material to have excellent strength-to-weight ratios and can be used at temperatures up to 1350°F.

W-545 will withstand higher stress levels than current disc alloys, at the same operating temperatures . . . or it will withstand equivalent stress characteristics at 100°F higher operating temperatures. W-545 is outstanding for turbine discs, couplings, shafts, valve stems, bolts, etc., in the missile, gas and steam turbine fields. W-545's nonmagnetic and high yield strength characteristics make it very desirable for low-temperature uses, such as retaining rings and wedges in electrical apparatus.

NICROTUNG is a new casting alloy for operation at elevated temperatures. Operating at temperatures of 1800°F and higher, Nicrotung is an ideal alloy for turbine blading.

For complete physical and chemical properties on both these NEW alloys, write today to: Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pennsylvania. J-05007

TURBINE DISCS

VALVE STEMS

COUPLING SHAFTS

BOLTS

YOU CAN BE SURE...IF IT'S Westinghouse

For more information, turn to Reader Service card, circle No. 465

What's new IN MATERIALS

vent-base cement for bonding cellulose acetate film to itself and to other materials. According to the producer, the adhesive dries rapidly and leaves no residual odor. Besides film, the adhesive can be used to bond cellulose acetate molded sections, extruded parts and castings.

Low Alloy Tool Steel Is Shock Resistant

Crucible Steel Co. of America, Oliver Bldg., Pittsburgh 22 has developed a low alloy tool steel for applications requiring unusual resistance to shock and impact, such as shear blades, impact extrusion tools, cold heading die and punches.

Known as LaBelle HT, the tool steel is currently being field tested in a number of industrial applications. For instance, in an aluminum extrusion application, LaBelle HT produced 25,000 pieces, whereas other shock steels produced about 1000 pieces. In another application, the tool steel produced 43,000 pieces compared to 8000 pieces for another tool steel.

Synthetic Sapphires Are Free from Strain

Strain-free synthetic sapphires in sizes up to ¾ in. square by ¼ in. thick have been developed recently by Bell Telephone Laboratories, 463 West St., New York 14. The sapphires are particularly useful for such optical parts as lenses, prisms, windows and lamp envelopes because they transmit light well out into the infrared and far into the vacuum ultraviolet regions.

How crystals are made

The sapphire crystals are made by a hydrothermal process which involves dissolving and recrystallizing aluminum oxide from an aqueous solution under high pressures and high temperatures; pressures of 20,000 to 50,000 psi and temperatures of 750 F and higher are used. Rate of growth varies with conditions, but typically ranges from 0.002 to 0.010 in. per day. (For information on another synthetic

Gast Rotary-Vane Design in Air Motors, Compressors and Vacuum Pumps is an advanced concept that is setting new high standards of efficiency for manufacturers of a great variety of original equipment.

In the manufacture of Gast units, the highly important rotor-shaft assemblies are brazed with Silvaloy 45 and 1200 Flux . . . using an induction heater for heat source. Each joint is as strong as the metals it joins and can be depended upon for thoroughly reliable service.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results for manufacturers in many fields. Call your nearest Silvaloy Distributor for information or technical assistance. ★ ★ ★ ★ ★

AMERICAN PLATINUM & SILVER DIVISION
231 N.J.R.R. AVENUE • NEWARK, N. J.

ROTARY AIR
GAST
PRODUCTS

GAST MANUFACTURING CORP. is one of the country's most creative manufacturers of rotary air motors, compressors and vacuum pumps for original equipment markets. The large plant is located at Benton Harbor, Michigan.

AMERICAN PLATINUM & SILVER DIVISION

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

113 ASTOR STREET • NEWARK 2, NEW JERSEY

THE SILVALOY DISTRIBUTORS

A.B.C. METALS CORPORATION
DENVER, COLORADO

BURDETT OXYGEN COMPANY
CLEVELAND • CINCINNATI
COLUMBUS • AKRON • DAYTON
YOUNGSTOWN • MANSFIELD • FINDLAY

DELTA OXYGEN COMPANY, INC.
MEMPHIS, TENN.

EAGLE METALS COMPANY
SEATTLE, WASH. • PORTLAND, ORE.
SPOKANE, WASH.

EDGCOMB STEEL OF NEW ENGLAND, INC.
MILFORD, CONN.

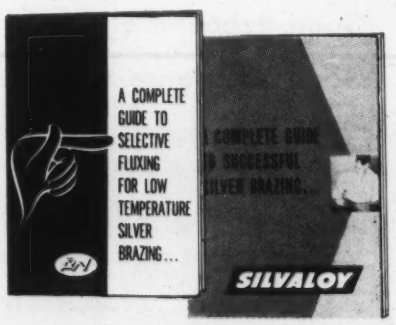
NOTTINGHAM STEEL & ALUMINUM CO.
CLEVELAND, OHIO

OLIVER H. VAN HORN CO., INC.
NEW ORLEANS, LOUISIANA
FORT WORTH, TEXAS • HOUSTON, TEXAS

PACIFIC METALS COMPANY LTD.
SAN FRANCISCO, CALIFORNIA
SALT LAKE CITY, UTAH
LOS ANGELES, CALIFORNIA
SAN DIEGO, CALIFORNIA
PHOENIX, ARIZ.

STEEL SALES CORPORATON
CHICAGO, ILL. • MINNEAPOLIS, MINN.
INDIANAPOLIS, IND. • KANSAS
CITY, MO. • GRAND RAPIDS, MICH.
DETROIT, MICH. • ST. LOUIS, MO.
MILWAUKEE, WIS.

LICENSED CANADIAN MANUFACTURER
ENGELHARD INDUSTRIES OF CANADA, LTD. • TORONTO • MONTREAL



Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

For more information, turn to Reader Service card, circle No. 516

ElastaCAST®

NEW STRUCTURAL MATERIAL

Stronger than Most Metals!

* Licensed under U. S. Pat. 2,764,565

Precision cast shapes to your specifications, this new extraordinary structural material offers unusual mechanical properties making it a much desired choice over metal, nylon and other non-metallics for many applications.

ElastaCAST*, a urethane rubber, utilizes inexpensive tooling to produce component parts at a **new low in unit costs.** Here are five of ElastaCAST's innumerable superior property advantages which make it a must in your requirements for progressive design and greater functional efficiency:

Extreme High Tensile Strength of 4200 to 7300 psi.
Wide Range of Hardness from 62 to 92 Shore A.
Excellent Abrasion and Tear Resistance.
Good Rebound Elasticity.
Good Resistance to Solvents and Ozone.

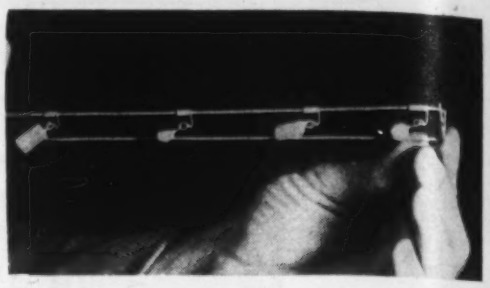
(Not Sold as a Casting Compound)

For complete details on this versatile material, write for the ElastaCAST Engineering Notebook. A competent staff of engineers and laboratory technicians await your product research and development problems.

ACUSHNET PROCESS COMPANY
NEW BEDFORD. MASSACHUSETTS
Producers of Precision-Molded Natural & Synthetic Rubber Parts

Address all communications to 750 Belleville Ave., New Bedford, Mass.

For more information, turn to Reader Service card, circle No. 459



Crop of crystals, *just removed from a high pressure reactor, was made by a new synthetic sapphire growing technique.*

sapphire growing technique, see M/DE, Sept '58, p 161.)

Synthetic ruby

Scientists at Bell Telephone Laboratories note that if the nutrient solution is "doped" with small amounts of a chromate, the resultant crystal is synthetic ruby, the color being a function of the amount of chromate added. The synthetic ruby has potential use in electronic devices.

Polyethylenes Available in Wide Density Range

Polyethylene resins are now available in a broad range of densities (0.915 to 0.960) from Bakelite Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. Bakelite has seven plants on stream for the production of low and high density resins and is said to be the first such company to produce both Ziegler and Phillips-type resins.

A number of grades are currently available with each grade specifically compounded for a particular type of fabrication, including blow molding, vacuum forming, injection molding, and film extrusion. Some of the company's high density resins are:

DGDB-4002 for film extrusion.

DGDB-4100 for contour and sheet extrusion and vacuum forming. It

DON'T MISS AN ISSUE — Changing your address? If so, please let us know two months in advance. With such notice, which we need for efficient operation, we will do our best to see that you don't miss an issue. Be sure to include your new postal zone number.

Strength

that comes only from forging and rolling

Strength is the first requirement of any crane wheel. Nothing else counts quite so much. This wheel has it.

The wheel was machined from a Bethlehem forged-and-rolled blank—a unique type of blank that is strong all over, and all the way through.

Bethlehem's forging-and-rolling method produces blanks with excellent grain flow and freedom from porosity. The metal down inside, as well as on the surface, is of uniform quality. This makes the machinist's job easier; he can work with confidence. The blanks can be turned, bored, faced, and hobbed with complete assurance of a good finished product.

You can obtain Bethlehem forged-and-rolled blanks in a wide range of sections, and in sizes from 10 to 46 in. OD. Use them when making crane wheels, gears, flywheels, pipe flanges, turbine rotors, sheave wheels, and similar items. Prices are competitive.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

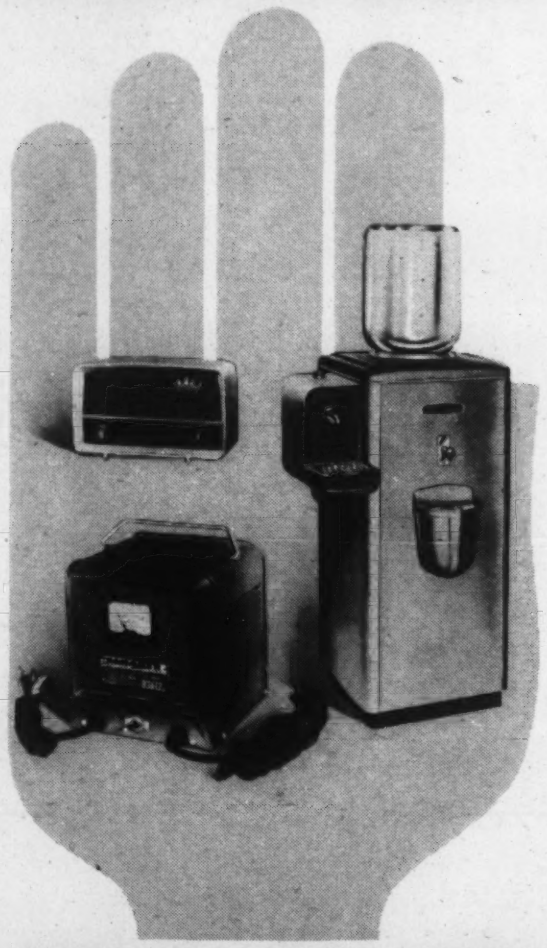
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 445

SELF-ADHERING MIRRO-BRITE "MYLAR"* METALLIZED AND LAMINATED



GIVES THE MAGIC TOUCH

of gleaming metallic highlights

TO YOUR PRODUCT

for added eye appeal

. . . greater sales appeal!

Want to dress up your product to outshine your competition? Mirro-Brite "Mylar" provides the perfect answer. Application is simple... peel off paper backing and press. Amazingly tough, non-tarnishable Mirro-Brite "Mylar" will stick permanently to its job of beautifying your product. Also available without pressure sensitive backing. Its versatility is unlimited for a wide variety of usages in tapes or cut-to-size panels. Many colorful finishes, laminations and embossed patterns.

*"Mylar" is DuPont's registered trade mark for its brand of polyester film.

Write Now for actual samples and prices.

[redacted]

DEPT. MDE 9, 101 W. FOREST AVE., ENGLEWOOD, N. J.

PIONEERS in METALLIZED MATERIALS!

Manufacturers of Mirro-Brite "Mylar," Acetate, Polystyrene and Butyrate.

For more information, circle No. 411

What's new IN MATERIALS

contains an antioxidant for high heat resistance.

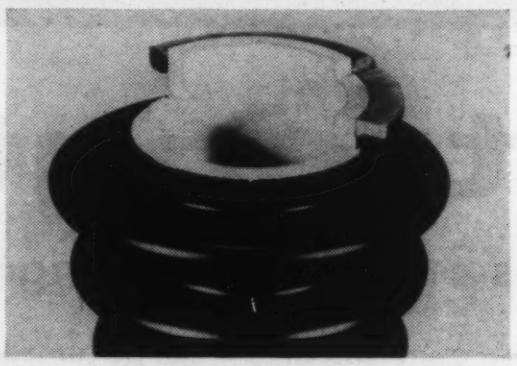
DGDA-4551 for extrusion coating.
DMDA-4901 for blow molding.
DMDA-600 for injection molding.
DMDA-6201 for injection molding. It has a higher melt index than DMDA-6001.

Aluminum-Iron Alloy Supplied in Thin Strip

An aluminum-iron, nonstrategic magnetic alloy is now available in production lot quantities from Carpenter Steel Co., Reading, Pa. Called 12 Alfenol, the material is a high permeability alloy available as unannealed cold rolled strip in thicknesses from 0.002 to 0.025 in. and in widths up to 3 in. (For information on another aluminum-iron alloy, see M/DE, Oct '57, p 186.)

The new magnetic alloy, developed by the Naval Ordinance Laboratory is expected to find use in magnetic tape pickup heads, servo and synchro laminations, and thin gage toroidal tape cores.

Carpenter says the alloy has good



Porcelain - to - aluminum seal—Shown here is the top of a porcelain bushing that has been bonded to aluminum. The seal is made by bringing hot porcelain in contact with molten aluminum under carefully controlled temperature and temperature-change conditions. The bonding process, still in the experimental stage, was developed by Westinghouse Electric Corp. The developer says the bonding technique will probably find use in electrical applications where the substitution of aluminum for steel and other materials is desirable.

Somers UNIGRAIN®

thin strip brass for deep drawing

Uniform fine grain size of Somers eyelet brass—less than .010 mm. (75X).

with *Fine Grain Finish*

Somers Brass Company is pleased to announce the availability of a new, unique annealing process which makes possible a uniform fine grain of less than .010 mm. which can be drawn to full 40% elongation.

Developed in cooperation with the Selas Corp. of America this new process makes it possible to deep draw Somers THIN STRIP and still obtain a fine grain which is easily buffed to a brilliant finish.

And this new Selas Furnace provides high production as well as close control of temper and uniformity. It is typical of the modern equipment with which Somers produces copper, brass and other alloys to rigid specifications between .010" and .00015".

If you have a problem with thin strip, let Somers experience help you. Write for confidential data blank or field engineer.

Somers Brass Company, Inc.
108 BALDWIN AVE., WATERBURY, CONN.

For more information, circle No. 467

Molding bag of FAIRPRENE® demonstrates extraordinary strength and durability

Shown above is the last stage in an internal molding process that uses an inflated bag of "Fairprene" synthetic rubber sheet stock as the core. This is where the bag undergoes greatest strain, being drawn through a 2½" opening in the formed tank. But bags of strong and flexible "Fairprene"* resist the wear and tear—permit more than 80 complete molding operations, as compared with only 20 when ordinary materials were used.

Structural Fibers, Inc., of Chardon, Ohio, found only "Fairprene" could withstand the extraordinary heat, pressure and abrasion involved in their internal molding process.

This is an example of the superior performance of "Fairprene" that might prove useful for your product or process. If you need material resistant to gas, oils, solvents or corrosive chemicals, abrasion or flex cracking—materials that retain their properties at −100°F. or 500°F. . . . or possess superior insulation or anti-stick properties, there's a Du Pont coated fabric or sheet stock to do the job. And to help you use these materials most effectively, you can call on free technical help from Du Pont. For more specific information on the variety of "Fairprene" materials available, mail the coupon.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
Chlorosulfonated Polyethylene • TFE-fluorocarbon • Butyl
Acrylic • Polyamide • Polyethylene • Polysulfide

SUBSTRATES

Fabrics

Cotton • Nylon • "Dacron"† • Asbestos
Glass • Rayon • TFE-fluorocarbon
Also elastomer sheet stocks without fabric inserts and cements

†*"Dacron" is Du Pont's registered trademark for its polyester fiber*

**"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.*

E. I. du Pont de Nemours & Co. (Inc.), Dept. MD-89
Fabrics Division, Wilmington 98, Delaware

Please send me further information about coated fabrics.

I am interested in using a coated fabric for _____

Name _____ Title _____

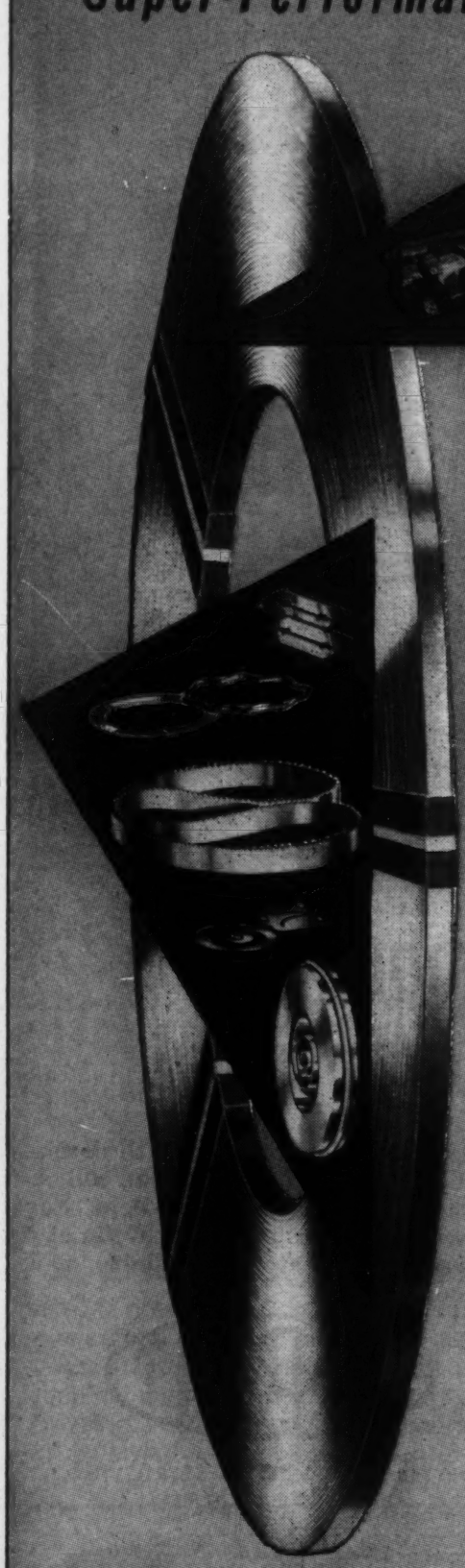
Firm _____

Address _____

City _____ State _____

For more information, turn to Reader Service card, circle No. 399

PURITY plays a part in SANDVIK Spring Steel's Super-Performance



Basic purity has a lot to do with Sandvik's ability to deliver top performance in so many difficult spring steel applications. This purity begins with the purest iron ore—obtained from Sandvik's own mines.

Step by step in the production of the quality strip steel, close control is held on the product. Only the purest materials, such as sulphur-free charcoal and sponge iron are used in the furnaces. The only return scrap used is from the Sandvik plant itself.

Sandvik supplies cold rolled specialty strip steels —

- **In special analyses for specific applications**
- **Precision-rolled thicknesses to fit your requirements**
- **In straight carbon and alloy grades**
- **Annealed, unannealed or hardened and tempered — scaleless or polished bright, yellow or blue**
- **With squdre, round or dressed edges**

Sandvik stocks a wide variety of qualities and sizes. In addition Sandvik has Rolling, Slitting, Edge-Filing and Hardening and Tempering facilities.

Write for the new Sandvik brochure and stock lists.

SANDVIK STEEL, INC.

1702 Nevins Road, Fair Lawn, New Jersey
Tel. SWarthmore 7-6200
In N. Y. C. ALgonquin 5-2200

Warehouses:
Fair Lawn, N. J. • Cleveland • Los Angeles

Branch Offices:
Cleveland • Detroit • Chicago • Los Angeles.

SANDVIK CANADIAN LTD.
P. O. Drawer 1335 Sta. O, Montreal 9, P. Q.

Works: Sandviken, Sweden

Sandvik Quality Steels

wear and abrasion resistance, good magnetic stability at temperatures up to 930 F, good resistance to salt spray, and good electrical properties.

Bearing Material Made of Bronze, Lead, TFE

A dry bearing material, developed in England and now available in this country from the Special Products Dept., U. S. Gasket Co., Plastics Div. of Garlock Packing Co., Camden 1, N. J., consists of a tin-plated steel backing on which is sintered a thin lining of spherical bronze impregnated with a lead-filled TFE resin. The impregnated bronze lining is coated with a thin layer of lead-filled TFE resin. (For more information see MATERIALS & METHODS, Sept '55, p 94.)

The material is supplied in strips 4 x 18 in. wide and 5 in. x 8 ft long. The strips are available in thicknesses of 0.044, 0.059, 0.075 and 0.091 in. with tolerances of ± 0.001 in.

Potential uses

The bearing material, called DU, is expected to find use in journal and thrust bearings and other sliding surfaces where lubrication is undesirable, impractical or unreliable. The material should be useful for bearings in washing machines, vacuum cleaners, kitchen equipment, refrigerators, fans and mechanical toys. In the automotive field, the bearing material has potential use in distributors, windshield wipers, and heating fans.

Properties

Numerous laboratory investigations in England and in this country show the bearing material has the following properties:

Wear resistance is about 0.4 x 10^{-7} in. per hr.

Coefficient of friction, with loads varying from 10 psi to 1500 psi and speeds varying from 40 to 1000 fpm, averages about 0.13. This is similar to values for oil-lubricated bearings.

Temperature range is from -328 F to 536 F; rapid temperature changes do not affect the material.

Abrasion resistance is good since the material contains no sticky fluid to trap dirt and carry it into the

For more information, turn to Reader Service card, circle No. 447

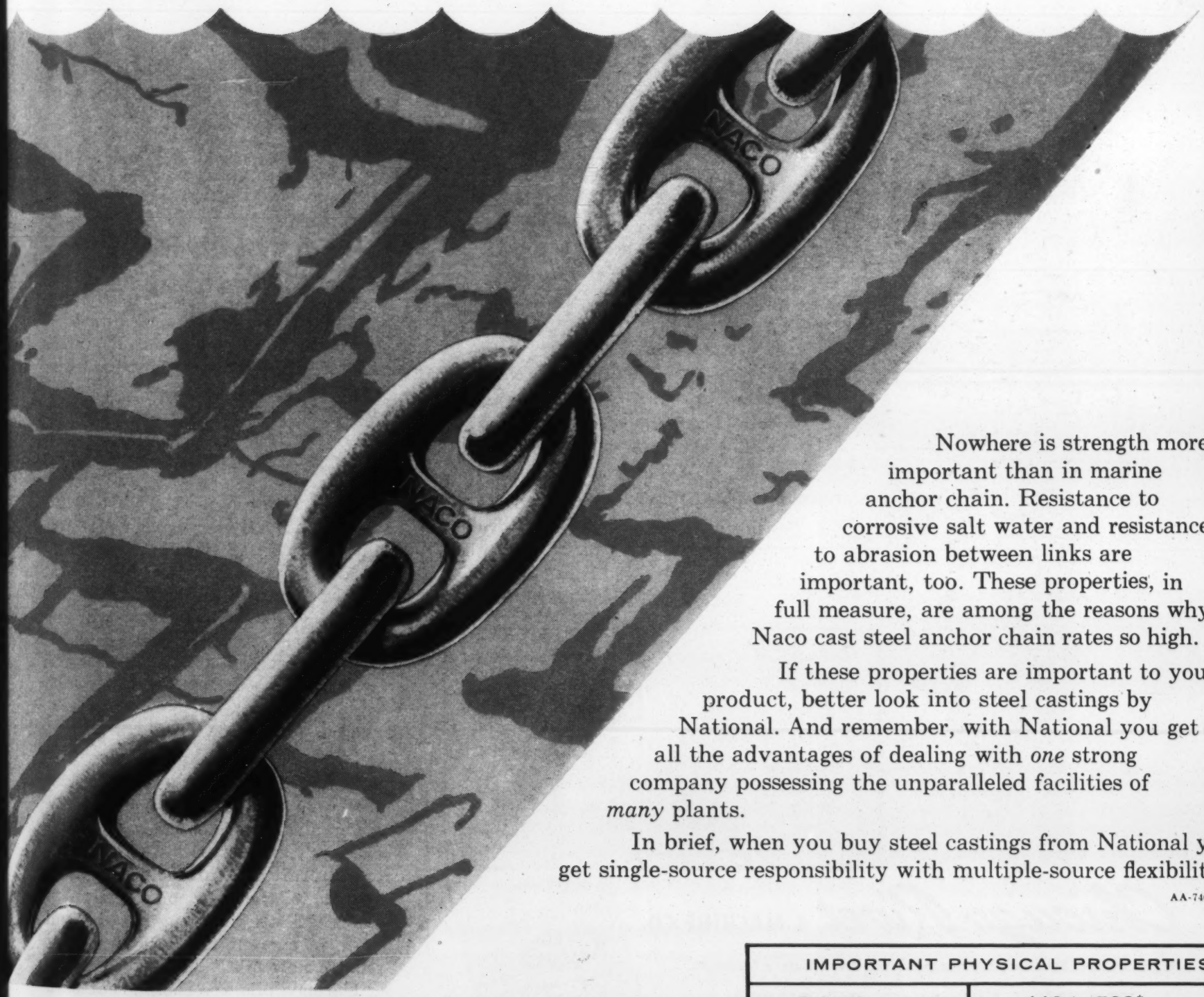
For more information, circle No. 509

your problem

strength?

NATIONAL STEEL CASTINGS

are the answer



Nowhere is strength more important than in marine anchor chain. Resistance to corrosive salt water and resistance to abrasion between links are important, too. These properties, in full measure, are among the reasons why Naco cast steel anchor chain rates so high.

If these properties are important to your product, better look into steel castings by National. And remember, with National you get all the advantages of dealing with *one* strong company possessing the unparalleled facilities of *many* plants.

In brief, when you buy steel castings from National you get single-source responsibility with multiple-source flexibility.

AA-7460

IMPORTANT PHYSICAL PROPERTIES	
Brinell	140 to 500*
Yield, psi	30,000 to 210,000*
Ultimate, psi	60,000 to 240,000*
Elongation, %	24 to 2

*Depending upon grade

NATIONAL MALLEABLE and STEEL **CASTINGS COMPANY**

Established 1868 *Cleveland 6, Ohio*

TIME TO LOOK AT COSTS

You need the answers to such questions as:

"Can a TUBULAR RIVET replace a solid rivet, screw, or bolt and thereby accelerate production?"

"Would a SPLIT RIVET with a decorative head improve product appeal?"

"Should a SELF-PIERCING RIVET be used and eliminate a drilling operation?"

"Can a cold headed part such as a SHOULDER RIVET serve as a fastener and also provide a bearing surface?"

"Would a TAPPED RIVET, made to receive a screwed-on assembly, simplify field service?"

These are typical questions asked of Chicago Rivet engineers because keen competition today makes necessary re-examination of production methods. No matter how complex or how simple your fastening problem may seem to be, get the cost saving advice that Chicago Rivet engineers can give. Send blueprint or sample assembly—no obligation.

There are *Chicago Rivet* Machines that will set

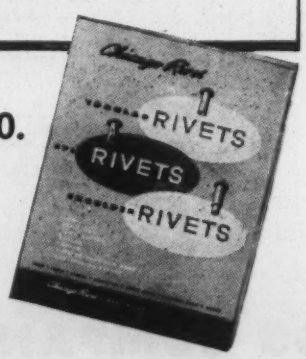
1 2 3 4 5 6

Tubular or Split Rivets At a Time

Chicago Rivet & MACHINE CO.

965 S. 25th Ave. · Bellwood, Ill. (Chicago Suburb) · Branch Factory: Tyrone, Pa.

FOR YOUR FILES—Rivet catalog describing 1388 standard tubular and split rivets and 26 single and multiple automatic rivet setters.



For more information, turn to Reader Service card, circle No. 451

What's new IN MATERIALS

rubbing zone of the bearing.

Water resistance is good and permits use of the bearing material in assemblies that operate submerged in water.

Chemical resistance varies with type of fluid. In the case of corrosive fluids, the steel backing should be protected with an electroplated corrosion resistant metal. Gasoline, paraffin and other solvents and waxes do not affect the bearing material.

Electrical characteristics are good, and the material does not generate static electricity because of its low electrical resistance.

Fabrication

The material can be fabricated by cutting, sawing, drilling, milling and reaming. It can be bent, pressed and embossed, and joined to other surfaces by means of countersunk dowels or screws.

Needed: Lubricants for Gas Turbine Engines

Present service temperatures for aircraft engine lubricants are about 250 F max, but with the introduction of gas turbine engines these temperatures will go up to 400 F and even to 600 F, warns Kerry L. Berkey of Wright Air Development Center.

Berkey, in a paper read before the SAE National Aeronautic Meeting, gave an idea of what the Air Force is doing in developing better gas turbine engine lubricants. He said the Air Force has been working toward an oil which is capable of extended operation at a temperature of 400 F.

New synthetic oils

"The latest series of gas turbine engines will operate on 7808 oils (organic diester materials) for the time being," Berkey said. "However, when a new oil becomes available chances are most or all of the present aircraft gas turbine engines will switch to the new oil. The next series of turbine engines beyond those in current use will absolutely require new oils."

The new oils are coming out of a development program initiated by the Propulsion Laboratory of Wright Air Development Center. Most of

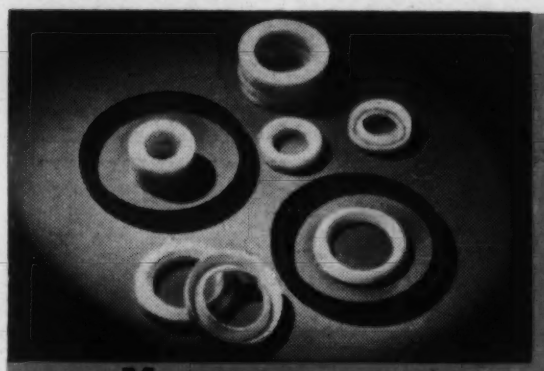
Tempilstik°. . . temperature indicating crayons

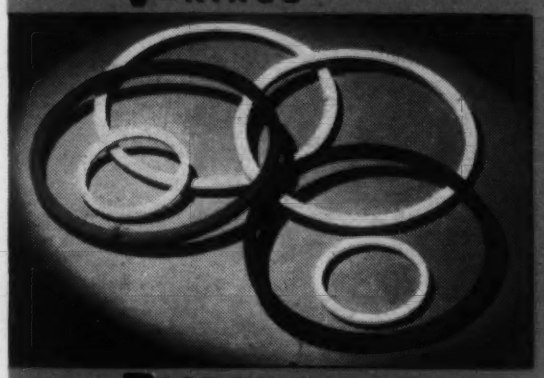
TEMPILSTIKS° are widely used as a standard method of determining temperatures in welding procedures, metal working and heat treating, steam trap maintenance, tire-retreading, plastic forming and hundreds of other heat-dependent operations. Available in 71 different temperature ratings . . . $2.00 each. Most industrial supply houses carry Tempilstiks°. If yours is among the few that do not as yet, then write direct to us for further information.

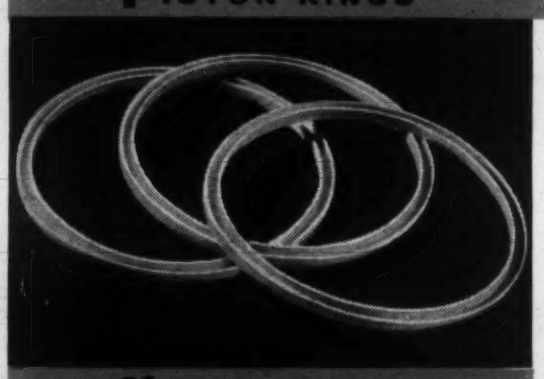
Tempil° CORPORATION • 132 West 22nd St., New York 11, N. Y.

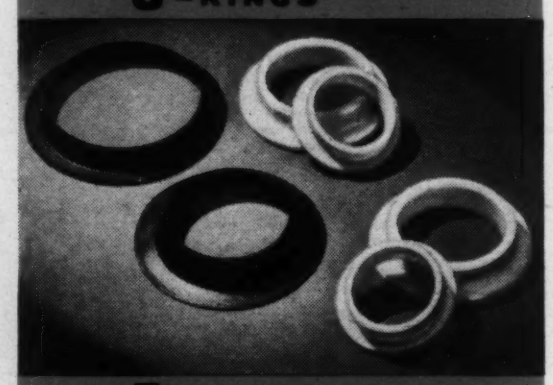
Visit us at Booth 422 — Nat'l Metal Expos. — Cleveland, Oct. 27-31.

For more information, turn to Reader Service card, circle No. 490


V-RINGS


PISTON RINGS


U-RINGS


FLANGES

CUPS

Chemiseal® hydraulic seals . . .

MADE OF
du Pont
TEFLON
T.F.E. fluorocarbon plastic

Chemiseal hydraulic packings are made for every type of static and dynamic seal. They are available in pure TEFLON or in Filled TEFLON (glass, graphite, etc.) depending upon the application and service requirement.

Preferred by Leading Engineers

Because Chemiseal hydraulic seals provide the reliability of chemicallyimperviousTEFLON, they are preferred by leading engineers for maximum security at vital points in aircraft and missile, automotive, marine, ordinance and industrial hydraulic systems.

Outstanding Advantages

Chemiseal hydraulic packings require no chemical inspection, have zero swelling in all hydrocarbons, new synthetic hydraulic fluids and solvents.

They offer unsurpassed antifriction properties, are tough, resilient, non-flammable, long wearing. They function equally well at any temperature from 100 degrees below zero to 500 degrees above.

Write for further information and samples for test.

United States Gasket Co.
Camden 1, N.J.

United States Gasket *Plastics Division of* **GARLOCK**

For more information, turn to Reader Service card, circle No. 438

What's new IN MATERIALS

the major oil companies, along with various chemical companies, are working on new fluids for this program.

How oils rate

Oils currently undergoing test in a gas turbine engine are:

Oil A: a mixture of complex esters containing anti-oxidation-corrosion, and anti-foam additives. The oil was run in the gas turbine engine for 53 hr and stopped because of excessive bearing temperature.

Oil B: a high molecular weight synthetic ester (not a sebacate, azealate or glycol) suitably inhibited. The oil was run a full 100 hr in the test engine (100 hr is considered a complete engine test).

Oil D: a mixture of complex esters containing anti-oxidation-corrosion, and anti-foam additives. The oil was run a full 100 hr in the test engine.

Oil E: a 50% polybutene, 50% heavy neutral mineral oil containing phenylalphanaphthylamine. The oil was run 70 hr and stopped because of excessive viscosity increase.

Oil G: a polyglycol containing additives. The oil was run 65 hr and stopped because of excessive viscosity increase.

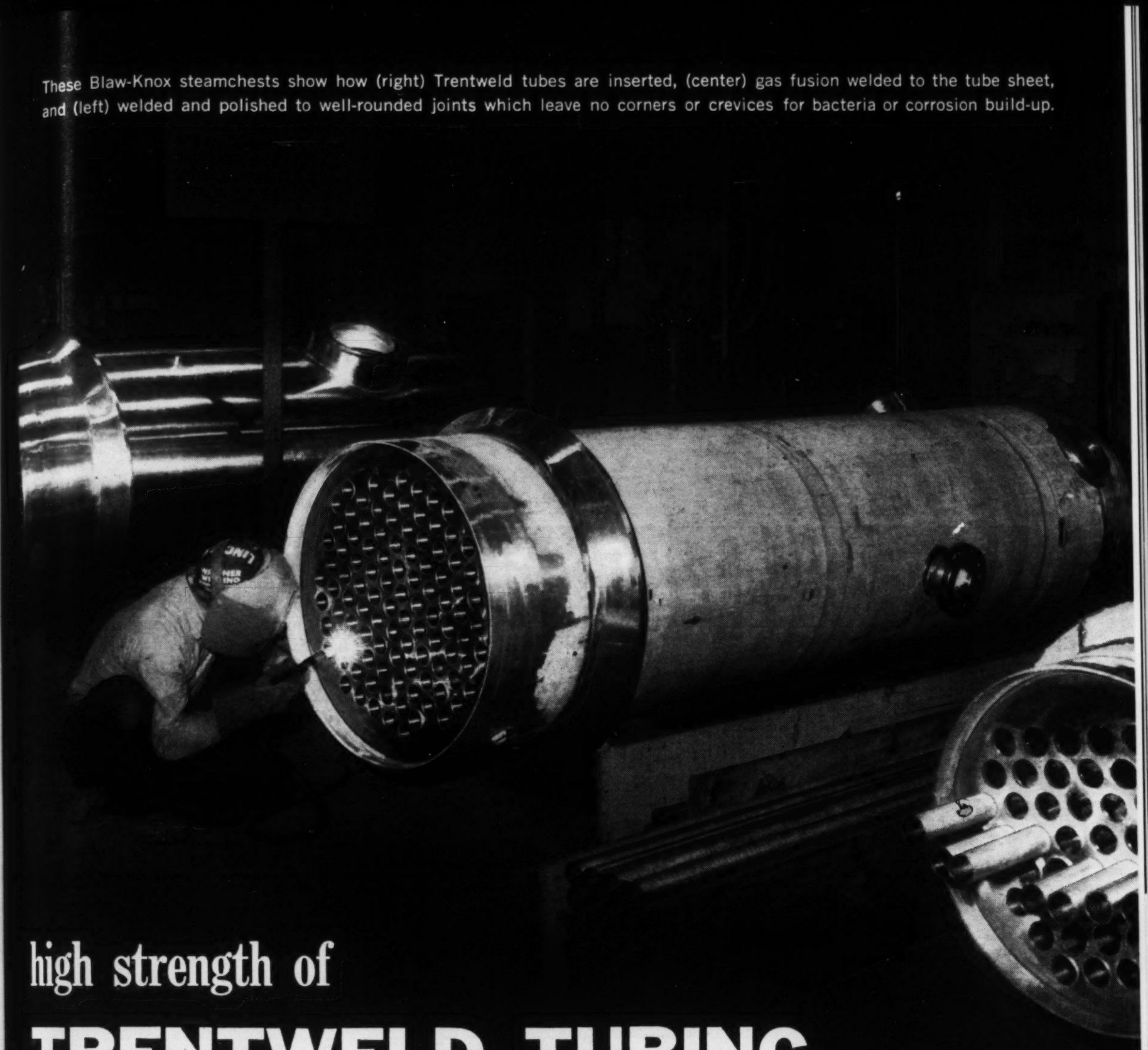
Oil H: a high molecular weight polyester containing conventional additives. The oil was run 55 hr and stopped because of excessive sludge and coke.

Oil K: a mineral oil containing conventional additives. The oil was run 20 hr and stopped because of excessive foaming.

Oil M: a methyl phenyl silicone containing no additives. The oil was run 11 hr and stopped because of excessive foaming. This was the first time the laboratory had been successful in operating an engine on a silicone oil; past attempts failed because of bearing overheating or excessive foaming. Studies are now underway to find a method for overcoming the apparent lack of lubricity in silicone oils.

Epoxy Resins Improved by Silicone Additive

The low temperature properties of common epoxy casting resins can be greatly improved by using a new



These Blaw-Knox steamchests show how (right) Trentweld tubes are inserted, (center) gas fusion welded to the tube sheet, and (left) welded and polished to well-rounded joints which leave no corners or crevices for bacteria or corrosion build-up.

high strength of TRENTWELD TUBING

reduces a steamchest's weight, increases its service life

Here's a case where the high strength of Trentweld® tubing reduced a steamchest's over-all weight while (1) increasing its service life, (2) improving heat transfer, (3) eliminating possible sanitation problems, and (4) reducing clean-up work.

These steamchests, made by Blaw-Knox Company for heating milk, frequently contain 3,000 feet of stainless steel tubing. Previously, Blaw-Knox expanded heavy-wall tubes into the tube sheet. Now, using welding techniques developed by Trent's Technical Service Group and Blaw-Knox welding supervisors, workers easily weld lighter gauge Trentweld tubes to the sheet and polish the joints. This eliminates any chance of bacteria growth during processing and of crevice corrosion during clean-up.

Trent's Technical Service Group can help you improve your product with Trentweld tubing, too. That's because Trent's exclusive welding process virtually eliminates any beads or undercuts, and because Trent cold works and anneals its tubing to make the weld as strong and corrosion resistant as the parent metal. The result? *Tubing that's as strong and uniform as tubing made by any other method.*

Mail coupon for catalog . . .

CONTOUR TRENTWELD TUBING is available in sizes ranging from ⅛" to 40" O.D. and grades including Hastelloy,* Zirconium, Zircaloy, Titanium, 19-9-DL – for applications in every industry.

*Trademark of Haynes Stellite Co.

CONTOUR TRENTWELD

TRENT TUBE COMPANY
Subsidiary of Crucible Steel Company of America

General Offices: East Troy, Wisconsin*

Gentlemen:
Please send me the *free* 48-page Trent tubing handbook.

*Name*_____
*Title*_____
*Company*_____
*City*_____ *Zone*____ *State*_____

***Or write: Trent Tube Company, Fullerton, Calif.**

For more information, turn to Reader Service card, circle No. 385

IMMEDIATE DELIVERY FROM STOCK

FANSTEEL

TANTALUM Sheet

Highest Purity, Greatest Ductility

Melting Point 5,425°F Density 16.6 g/cc

FANSTEEL

Molybdenum "D" Sheet

Deep Drawing Grade

Melting Point 4,752°F Density 10.2 g/cc

MADE QUICKLY To Your Specifications

FANSTEEL

COLUMBIUM

Sheet, Rod Wire, Tubing and Fabricated Forms

Melting Point 4,380°F Density 8.57 g/cc

FANSTEEL

TUNGSTEN

Sheet, Rod Wire and Fabricated Parts

Melting Point 6,192°F Density 19.3 g/cc

FANSTEEL

77 METAL

Intricate Shapes, Rods and Bars

Tensile Strength 85,000 psi Density 14.7 g/cc, avg.

Technical Assistance

Fansteel metallurgists and engineers are available to assist you in studying the money-saving possibilities and performance advantages of using Fansteel metals in your product. You will find news of how others are using Fansteel metals in our publication, FANSTEEL METALLURGY. Send us your name and address and we will be glad to send you copies as published. No cost or obligation.

K586A

FANSTEEL

Metals and Fabrication Division

FANSTEEL METALLURGICAL CORPORATION

NORTH CHICAGO, ILLINOIS, U. S. A.

For more information, turn to Reader Service card, circle No. 463

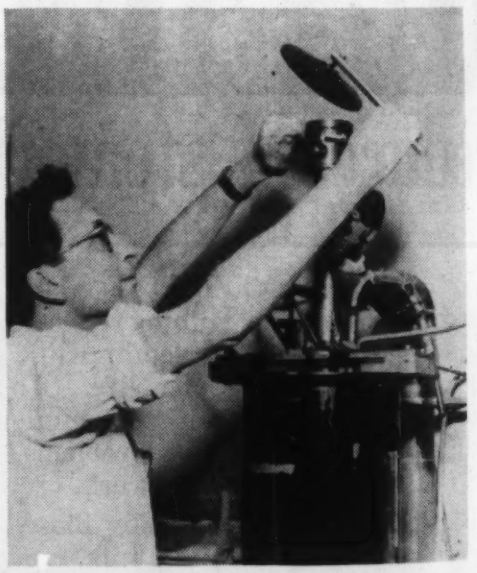
PROPERTIES OF SYL-KEM 90

Viscosity, cs	10-12
Specific Gravity	0.99-1.0
Boiling Point, F	365-375
Min Flash Point, F	345
Min Fire Point, F	390
Solubility	
Water	Nil
Organic Solvents	Complete

organo-functional silicone, according to Dow Corning Corp., Midland, Mich. Identified as Syl-Kem 90, the organo-functional silicone is an epoxy-siilcone combination with an epoxy group on each end of the molecule. Syl-Kem 90 is the newest addition to the company's Syl-Kem family of silicon chemicals. (For information on another of the company's silicon chemicals see M/DE, Aug '57, p 145.)

Intermetallic Becomes Magnetic When Cold

Ferromagnetism at low temperatures has been discovered in an intermetallic compound (zirconium zinc) which does not contain any of the commonly known ferromagnetic elements such as iron, cobalt, nickel, chromium, manganese and a few rare earth metals. Zirconium zinc becomes ferromagnetic at extremely low temperatures and its ferromag-



***Researcher Matthias** adjusts samples of zirconium zinc in a cryostat preparatory to measuring the magnetic properties of the compound at low temperatures. The compound becomes magnetic when cold.*

Design for full production efficiency: Continuous-Cast Bronze Castings.
Lower material costs, faster production, better products. Certainly a powerful set of reasons for evaluating Asarco's unique process of casting shapes in continuous lengths. The alloys produced by continuous casting are in accord with SAE, ASTM, and government specifications but their performance is demonstrably superior to similar alloys cast other ways. So superior in hardness, tensile, yield, and impact strength, that you may be able to substitute an Asarcon bronze for a high-cost aluminum or manganese bronze. You get the shape you need in the exact lengths you need, with minimum clean-up necessary, machinable on high speed machines. Immediately available in 260 *stock* sizes: Asarcon 773 (SAE 660) Bearing Bronze, solids and tubes, in lengths up to 105 inches. Write today for free booklet on Asarco continuous-casting to Continuous-Cast Products Department, American Smelting and Refining Company, Barber, N. J.; on the West Coast, Kingwell Bros., Ltd., 457 Minna St., San Francisco; in Canada, Federated Metals Canada, Ltd., Toronto and Montreal.

CONTINUOUS-CAST DEPARTMENT OF

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

For more information, turn to Reader Service card, circle No. 368

metals ... ...to match man's imagination

Conventional metals can no longer provide the solution to design, construction and performance problems confronting the aviation and missile industries, among others. That's why metallurgists and technicians in Wallingford's all-new laboratories are constantly researching metals that will keep pace with the imaginativeness of designers and engineers.

Now, Wallingford can deliver, *from available stock,* many of these stainless steels and super metals with special characteristics and properties:

SUPER ALLOYS

A 286 AM 350 AM 355
M 252 N 155 R 235 V 36
Rene 41 Zirconium (vacuum annealed)
Haynes 25 Hastelloy B, C and X
19-9 DL

FACILITIES FOR WIDTHS UP TO 27" — THICKNESSES DOWN TO .001 — EXTREMELY CLOSE TOLERANCES MAINTAINED.

Whatever your requirements, Wallingford can help you. Write to The Wallingford Steel Co., Wallingford, Conn.

THE WALLINGFORD STEEL CO.

Progress in Metals for over 36 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy
WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 376

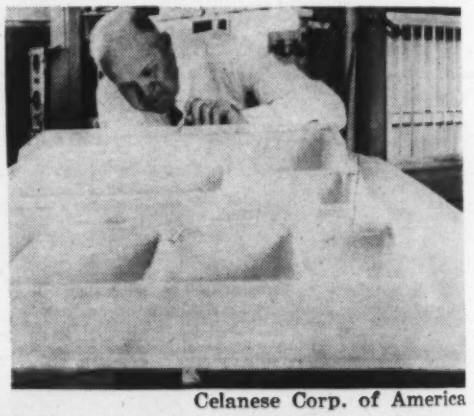
What's new IN MATERIALS

netic characteristics are similar to, and of the same order of magnitude as those exhibited by conventional ferrites at room temperatures.

The discovery, made by B. T. Matthias at Bell Telephone Laboratories, indicates that ferromagnetic and perhaps anti-ferromagnetic compounds may be formed by the combination of many more metals than had previously been supposed.

Carbon-Corrected Bars Supplied Ready-to-Use

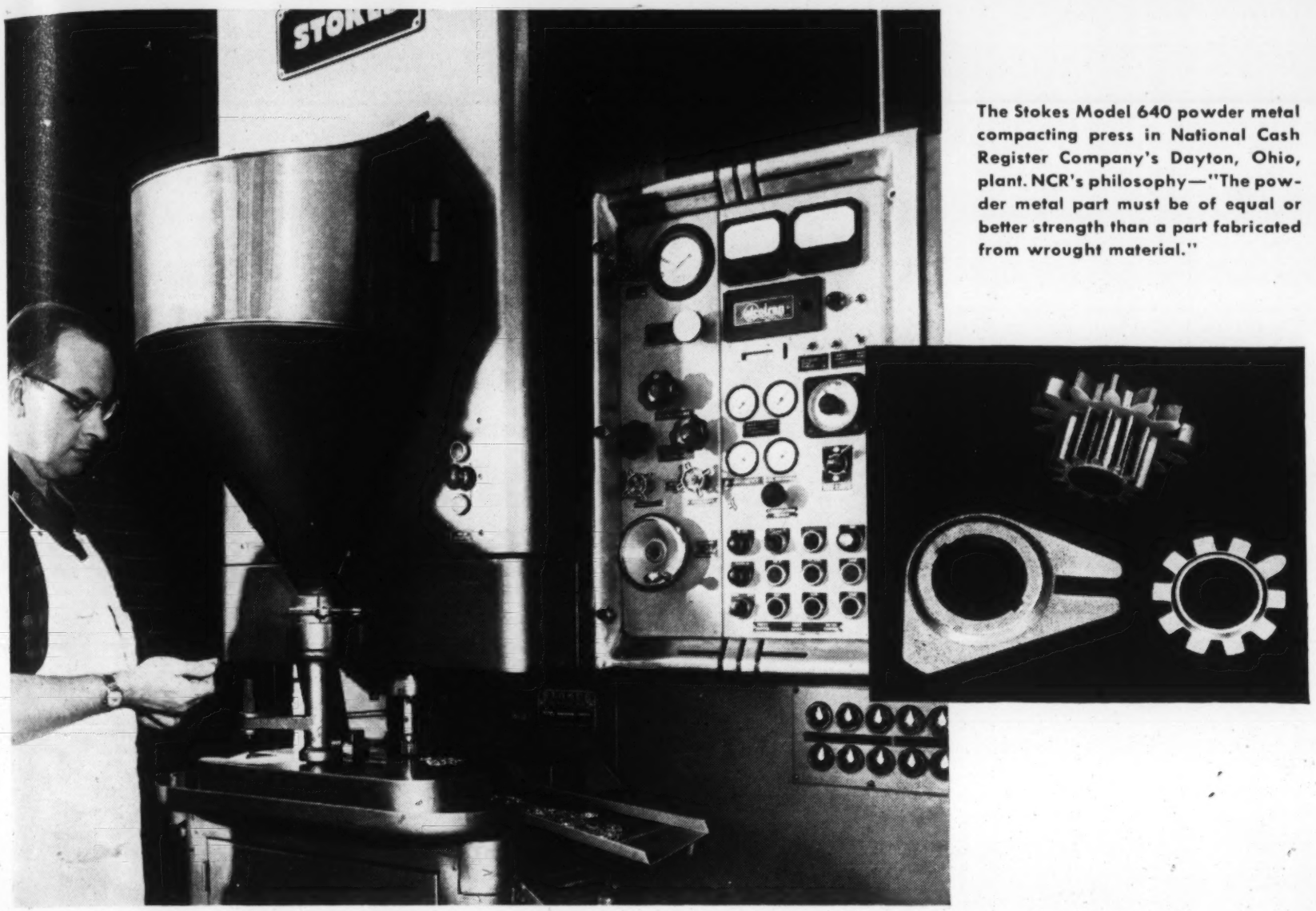
Ready-to-use carbon-corrected steel bars are now commercially available from Thomson Industries, Inc., Manhasset, N. Y. Prior to the introduction of the new material, carbon-corrected steel bars had to be hardened, ground and straightened by



Celanese Corp. of America

More uniform plastics parts— The polyethylene refrigerator door liner shown here illustrates the type of product that can be formed on a new air-slip or "bubble gum" plastics forming machine. Developed by Welding Engineers, Inc., Norristown, Pa., the plastics thermoforming method is said to produce parts with more uniform wall thicknesses than any other thermoforming method.

In the air-slip technique a sheet of thermoplastic material is first heated and softened, then blown into a bubble of predetermined size. The mold is raised into the bubble's cavity, the air is exhausted and the bubble is pulled down around the mold. The method achieves uniform wall thicknesses because the pre-stretched plastic does not touch the mold until the sheet is fully draped over it.



The Stokes Model 640 powder metal compacting press in National Cash Register Company's Dayton, Ohio, plant. NCR's philosophy—"The powder metal part must be of equal or better strength than a part fabricated from wrought material."

National Cash Register rings up savings through powder metallurgy...

The Stokes Model 640 50-ton powder metal press, at the Dayton, Ohio, plant of National Cash Register Company, has proved a valuable tool in the production of precision gears and parts for cash registers and accounting machines. In 1957, over 250 different high-density parts were made by powder metallurgy—in early '58, 47 additional parts went into production.

The economic benefits of this process have also been proved. A cost analysis of 54 parts shows substantial savings per year through lower direct labor costs in machining and inspection. More complex parts are continually being introduced—parts with hubs, steps, and thin projections—made possible by press equipment such as the Stokes 640.

The Stokes Model 640 offers up to five press motions with independently adjustable compression, fill and ejection points . . . each with direct reading position indicators calibrated to .001". This set-up versatility is teamed with operating simplicity that enables economical long or short runs, and permits easy re-runs of jobs on which set-up standards have been established.

Investigate the proved potential of powder metal pressing . . . not only for ways to cut costs and save metal over conventional machining, but also for ways to get properties of metals, alloys and mixtures not attainable by other techniques. Ask for a production and economic analysis on your own parts. Stokes' facilities include sample production, punch and die design and fabrication, and operator instruction. Stokes Engineering Advisory Service is ready to serve your powder metallurgy needs, whether large or small.

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 508

Plaskon **Polyesters are**

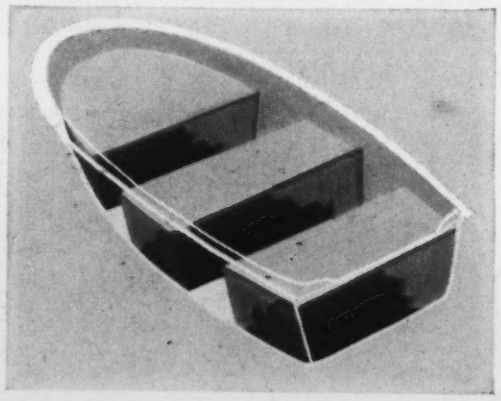
GOING

No doubt about it, polyesters are really going places—and fast! There are many good reasons for this . . . these versatile materials offer great freedom of design; unique color, translucency and surface effects; and dependable service, to mention only a few. As an example, note the great variety of products pictured here—including laminates, premix parts and polyurethane foams—all made with PLASKON Polyester Resins.

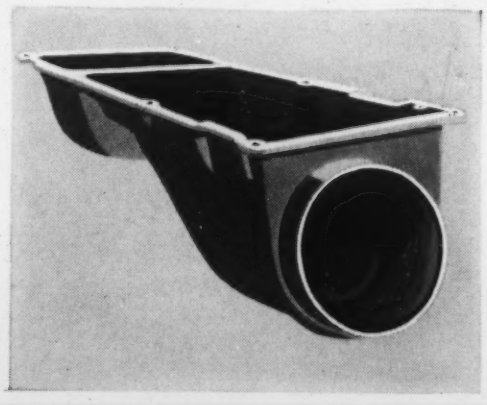
Wherever great strength combined with light weight are primary requirements, especially in relatively large units, PLASKON Polyesters—reinforced with glass fibers or other materials—are likely candidates. Other outstanding advantages: excellent electrical insulation, dimensional stability, a hard durable surface that resists weathering and chemical corrosion, good colorability—opaque or translucent.

PLASKON Polyesters play a leading role, too, in the booming market for polyurethane foams. Strong, *rigid* foams for thermal and acoustical insulation, flotation chambers, or protection against heat, cold, sound—flexible foams for vibration or impact absorption . . . whatever type of polyurethane you're looking for, we can supply the right PLASKON Polyester.

If you would like to know more about PLASKON Polyester Resins — and how they can serve you — **write to** Plastics and Coal Chemicals Division, 40 Rector Street, New York 6, New York. In Canada: Allied Chemical Canada, Ltd., 1450 City Councillors Street, Montreal, Canada.



POLYURETHANE FOAMS
PLASKON Polyesters for rigid foams can be foamed easily in place (as in this boat hull or in wall partitions) or in inexpensive molds on a batch or continuous basis.



PREMIX MOLDING
Cost-saving premix operation permits the rapid molding of reinforced parts with varying thicknesses, intricate contours or molded-in inserts. Used for automobile heater and radio speaker housings.

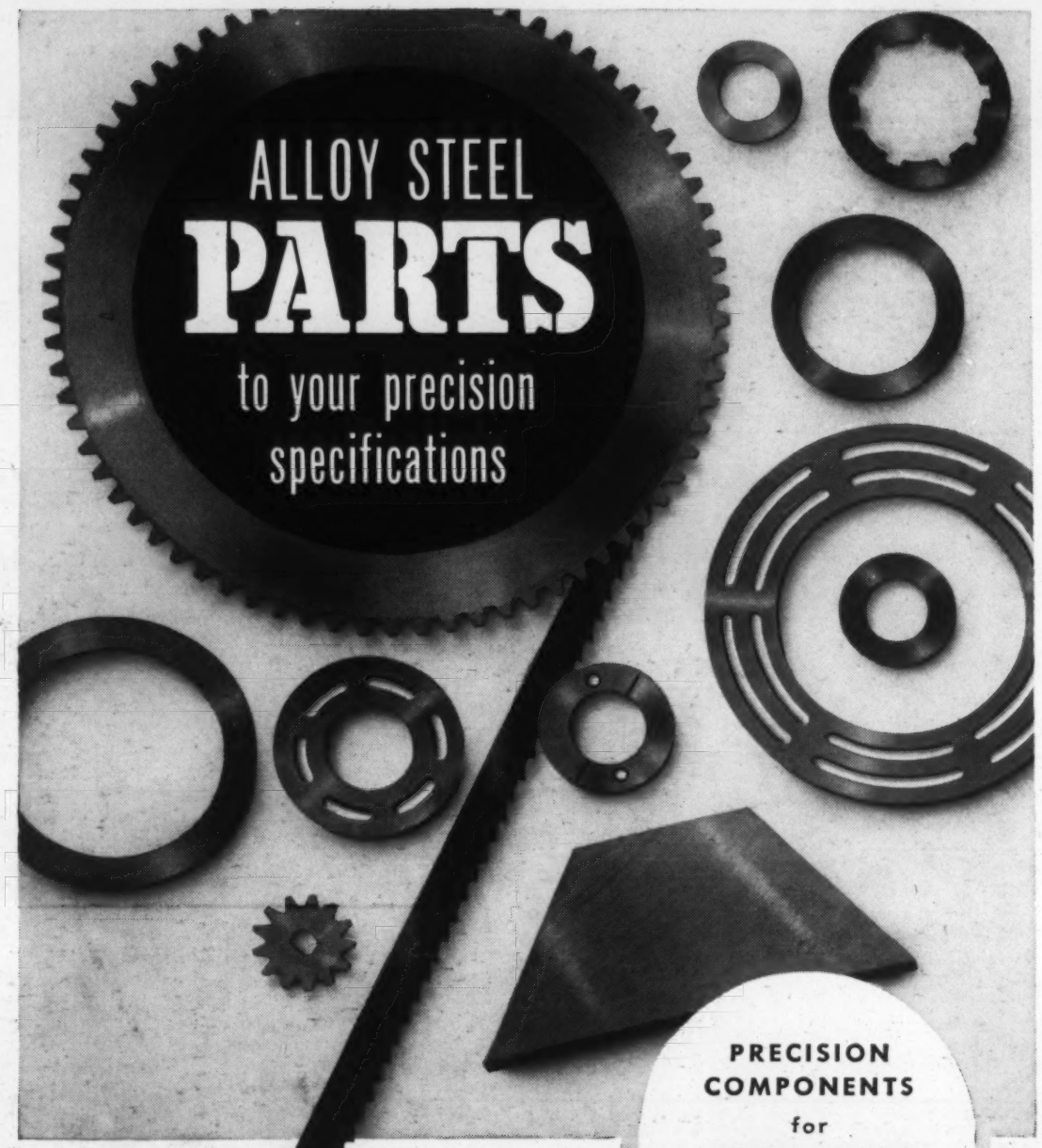
PLACES

MATCHED METAL MOLDING
For exact dimensional reproduction in every part. Molded under pressure and heat in metal molds to assure consistent mechanical performance, physical properties and rapid production. Examples: chairs, luggage, machine housings.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.
In Canada: Allied Chemical Canada, Ltd., 1450 City Councillors Street, Montreal

Allied Chemical

(Printed in U.S.A.)


ALLOY STEEL
PARTS
to your precision specifications
PRECISION COMPONENTS for AMERICA'S AIRCRAFT, AUTOMOTIVE and ALLIED INDUSTRIES

VOLUME REQUIREMENTS
delivered ***ON TIME*** *... by*

ATKINS B-W CONTRACT DIVISION

Call on ATKINS' complete production facilities and more than 100 years' design and manufacturing experience to supply *flat alloy-steel parts* for your product.

ATKINS *B-W* will produce parts any size or hardness, machined to any desired finish or tolerance . . . for automotive and aircraft engines and frames, presses and many other types of industrial equipment. Typical items are clutch plates and valve discs; flat steel machine parts; bars, spacer rings and washers; discs, knives and blades for any cutting or scraping operation.

Prompt delivery to meet your production schedule. Engineering service available.

Address inquiries, including full specifications and/or blueprints, to

ATKINS SAW Contract Division
BORG-WARNER CORPORATION
INDIANAPOLIS 9, INDIANA

ATKINS B-W BORG-WARNER

ATKINS Silver Steel SAWS

For Over 100 Years a Distinguished Name in American Industry!

For more information, turn to Reader Service card, circle No. 448

What's new IN MATERIALS

Special machining *is performed at Thomson Industries, Inc. on a carbon-corrected steel bar.*

the customer before using.

Thomson, which is supplying the bars under the name 60 Case, grinds, straightens and hardens the carbon-corrected bars to Rockwell C60. The bars are obtained from Union Drawn Steel Div., Republic Steel Corp.

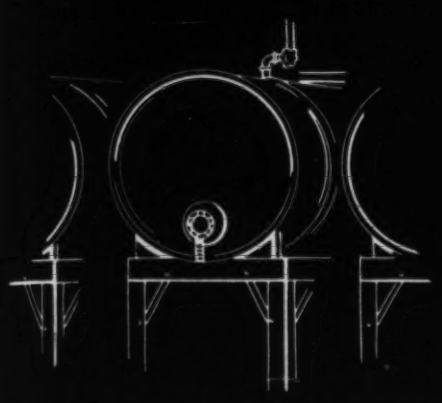
After carbon correction and hardening, the bars have a tensile strength of approximately 335,000 psi and a specified surface hardness of Rockwell C60 to a min depth of 0.040 in. in ¼-in. dia bars, and 0.100 in. in 4-in. dia bars. The steel bars are supplied in lengths up to 14 ft, with or without special machining.

Plasma Jet Applies Metallic Coatings

A new spraying technique has been developed which uses a plasma jet for applying metallic coatings to cold metal surfaces. A plasma jet works by directly transferring the energy from an electric arc to an ionized gas medium creating temperatures up to 25,000 F. The spraying technique, called Plasma Spray and developed by Giannini Plasmadyne Corp., 3839 S. Main St., Santa Ana, Calif., is capable of vaporizing and spraying tungsten which has a melting point of 10,600 F—in fact, the developer says the technique is capable of vaporizing and spraying any known element.

The velocity of the jet is 13,000 fps, yet it can be easily handled and monitored by control instruments. High spraying velocities in combina-

DESIGNED IN CELANESE FORTIFLEX . .



DRUM VALVE ASSEMBLY

MOLDED IN FORTIFLEX BY DELAWARE BARREL & DRUM CO., INC., WILMINGTON, DEL.

New Delaware drum valve is a Fortiflex-inspired design improvement

When corrosive materials come in steel or plastic drums, this is the spigot to thread into the bung hole! The valve—molded in one part—is made entirely of Fortiflex . . . resistant to acids and alkalis, heat and cold, with economical molded-in threads. Result: longer, trouble-free, dependable, corrosion proof service life.

Fortiflex is presently available in four melt indexes developed to accommodate a wide range of conditions and applications of interest to designers and manufacturers. For more information and/or test quantities, use the coupon.

Celanese® Fortiflex®

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	$N^{25}D$	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hrs. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0

Celanese Corporation of America, Plastics Division,
Dept. 102-S, 744 Broad Street, Newark 2, N. J.

Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16

For more information, turn to Reader Service card, circle No. 507

Shown 1/16 actual size

HACKNEY shapes meet needs of a changing world

Missiles! Moons! Rockets! Old, familiar words that mean new, unfamiliar problems for design and production engineers.

They are challenging words, too, to our engineers who are called upon to apply the *Hackney Method*—deep drawing shapes and shells from cold metals—to provide practical, economical answers to Space Age engineering problems.

The photo above shows how *Hackney Methods,* familiar for many years to engineers in many industries, can produce deep drawn, seamless parts for missiles which have maximum strength with minimum weight.

For detailed information about *Hackney Methods,* and their application to your design and production problems, write:

Pressed Steel Tank Company

Manufacturer of Hackney Products

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 460

What's new IN MATERIALS

tion with high temperatures are said to produce a smooth, dense coating that adheres well to the base metal.

The spraying technique is expected to be used for applying metallic coatings to missile and aircraft parts, pump and bearing surfaces, and combustion chamber valves.

Sealing Tape for Glass

A vulcanized rubber tape for sealing glass to glass, glass to metal, and metal to metal has been developed by Pittsburgh Plate Glass Co., Suydam Div., Island and Preble Aves., Pittsburgh 33. Known as No. 1072 Butene Sealing tape, the material has good resistance to ultraviolet rays and retains its elasticity after long-time exposure to weather. It withstands continuous exposures at temperatures from —45 F to 250 F.

The tape is recommended for sealing glass and metal aircraft, automotive, marine and appliance parts.

Ceramic Coated Wires Withstand High Heat

Recent trends in the electrical industry have been toward developing equipment to operate at high temperatures. Service temperatures of both military and industrial electrical equipment are rapidly approaching the limit for present organic insulating materials. To meet the demand for greater heat resistance a number of companies and research organizations have come up with ceramic coated wire.

1. Flexible coating

A flexible ceramic coated copper wire was described recently by scientists at a meeting of the American Ceramic Society in Pittsburgh. The new development, now undergoing pilot plant evaluation, is the result of the combined research effort of ceramic specialists at Battelle Memorial Institute and at General Electric Co. The coating is applied by firing it on the wire in a controlled atmosphere furnace. Tests show it has greater heat resistance

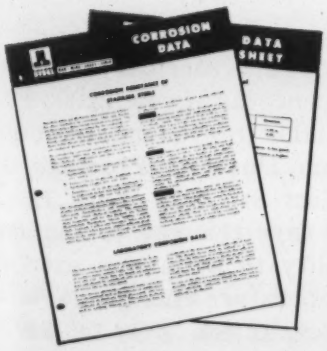
For more information, circle No. 472 ➤

New Sendzimir Mill

produces stainless steel sheets to extremely close tolerances in widths up to 48 inches

This new Sendzimir mill, complete with annealing, pickling, skin pass and other equipment, was designed and engineered for the exclusive production of the highest quality stainless sheet and strip.

It is located at the Louisville, O., plant of J & L's Stainless and Strip Division. For complete information on the Division's flat rolled stainless products, write our Detroit sales office today.



Write for these Technical Data:

1. Laboratory Corrosion Data.
2. Data Sheets (please specify the grades in which you are interested).

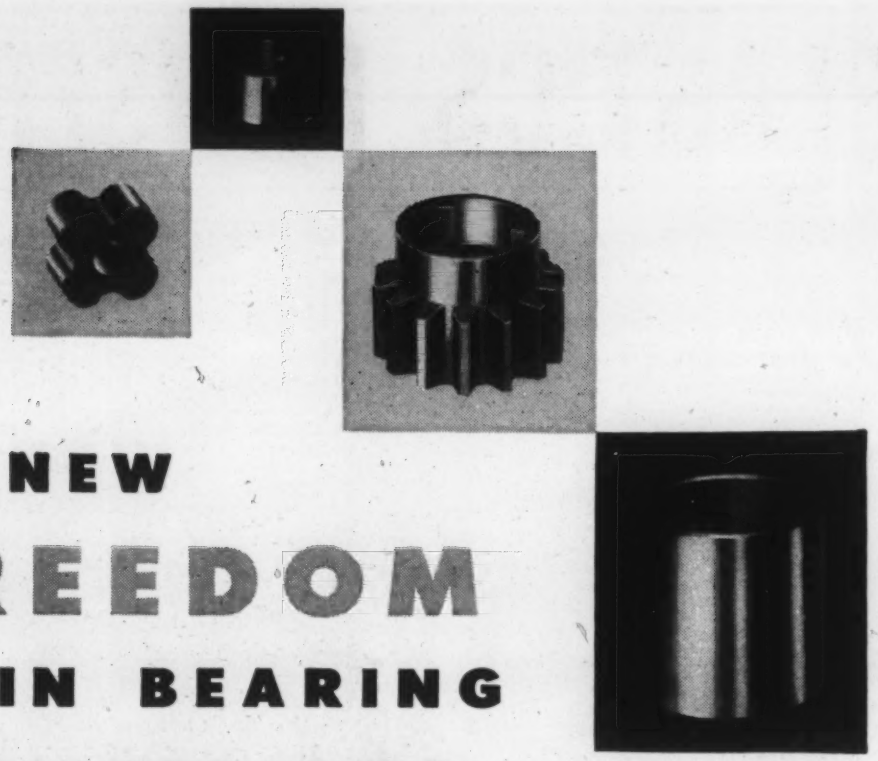
Improve your Products with . . .

JL STEEL STAINLESS

BAR • WIRE • SHEET • STRIP

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

For more information, turn to Reader Service card, circle No. 472

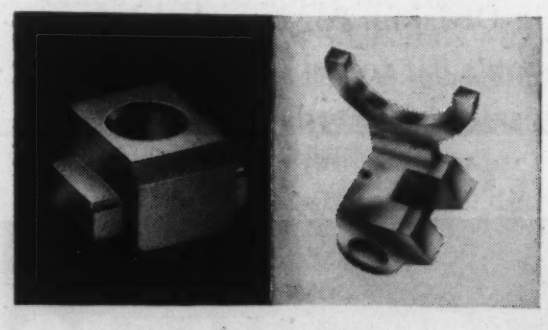


A NEW
FREEDOM
IN BEARING
APPLICATIONS

Availability of Sintered Powdered Metal Bearings and machine parts from a fully competent and technically responsible source opens the way to improvements in mechanical products.

Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

For more information, turn to Reader Service card, circle No. 429

than present commercial wire insulated with organic coatings.

2. Heat resistant coating

Consolidated Electrodynamics Corp., Pasadena, Calif., and Sequoia Wire & Cable Co., Redwood City, Calif., have signed an agreement giving Sequoia the right to manufacture and market ceramic coated wire using Ceramicite, a ceramic insulating material developed by Consolidated. According to Consolidated, Ceramicite coated wire can be wound around a part twice the diameter of the wire and subjected for 1000 hr to a continuous temperature of 1000 F without damage to the insulation. The ceramic coated wire is also said to have good thermal shock and abrasion resistance.

Silver-Striped Brass

Designed to enhance the appearance of giftware, costume jewelry, compacts, cigarette boxes, novelty items and other metal products, silver-striped brass is now available in widths up to 3½ in. and in thicknesses up to 0.060 in. from Metals & Controls Corp., General Plate Div., Attleboro, Mass. The silver stripe is permanently bonded to the base metal in single or multiple widths up to a total of six stripes per flat length. The stripe is said to withstand normal bending 1/32 in. away from and parallel to the stripe edge. Called Silver Inlay Stripe, the material is supplied in long flat lengths and in coils.

Ceramic Parts Resist Rapid Heat Changes

Pressed ceramic parts able to withstand such thermal changes as water quenching from 2200 F are now available in production lot quantities from Duramic Products, Inc., 262-72 Mott St., New York 12. The company says the key to the material's ability to withstand extremely rapid temperature changes is its zero thermal expansion over a 2400 F temperature range.

Designated Thermo Shock HT-2, the ceramic parts are supplied in sizes up to 2 in. in dia and 2 in.

CYANAMID

PLASTICS NEWSFRONT

Plastic Drink Dispensers Take Rugged Fountain Use

These attractive over-counter soft drink dispensers must resist impact, denting, corrosion, staining and scratching. So the Cornelius Company molds base, front and back panels of tough CYMEL® 1077 melamine plastic, which also provides the advantage of light weight—important in shipping and installing. Dispensers can be kept sanitary simply by washing with hot water and soap or detergent. Ordinary care will keep them bright and gleaming for a fountain's lifetime.

Lightweight and Portable— New Idea in Business Machines

This midget Underwood Add-Mate electric adding machine weighs just 7½ pounds. It can be toted easily from desk to desk or office to home, and slipped out of sight in a drawer when not needed. Contributing to its light weight, handy size, and durability is the attractive two-toned, two-piece housing molded of CYMAC® 201 methylstyrene-acrylonitrile copolymer. This plastic is tough, hard, and resistant to heat, staining and denting. Unharmed by the diester lubricant applied to the mechanical assembly, the CYMAC housing has the extra advantage of chip-proof molded-in color. This elimination of finishing simplifies manufacture.

Plastic Pipettes, Break-resistant and Boilable

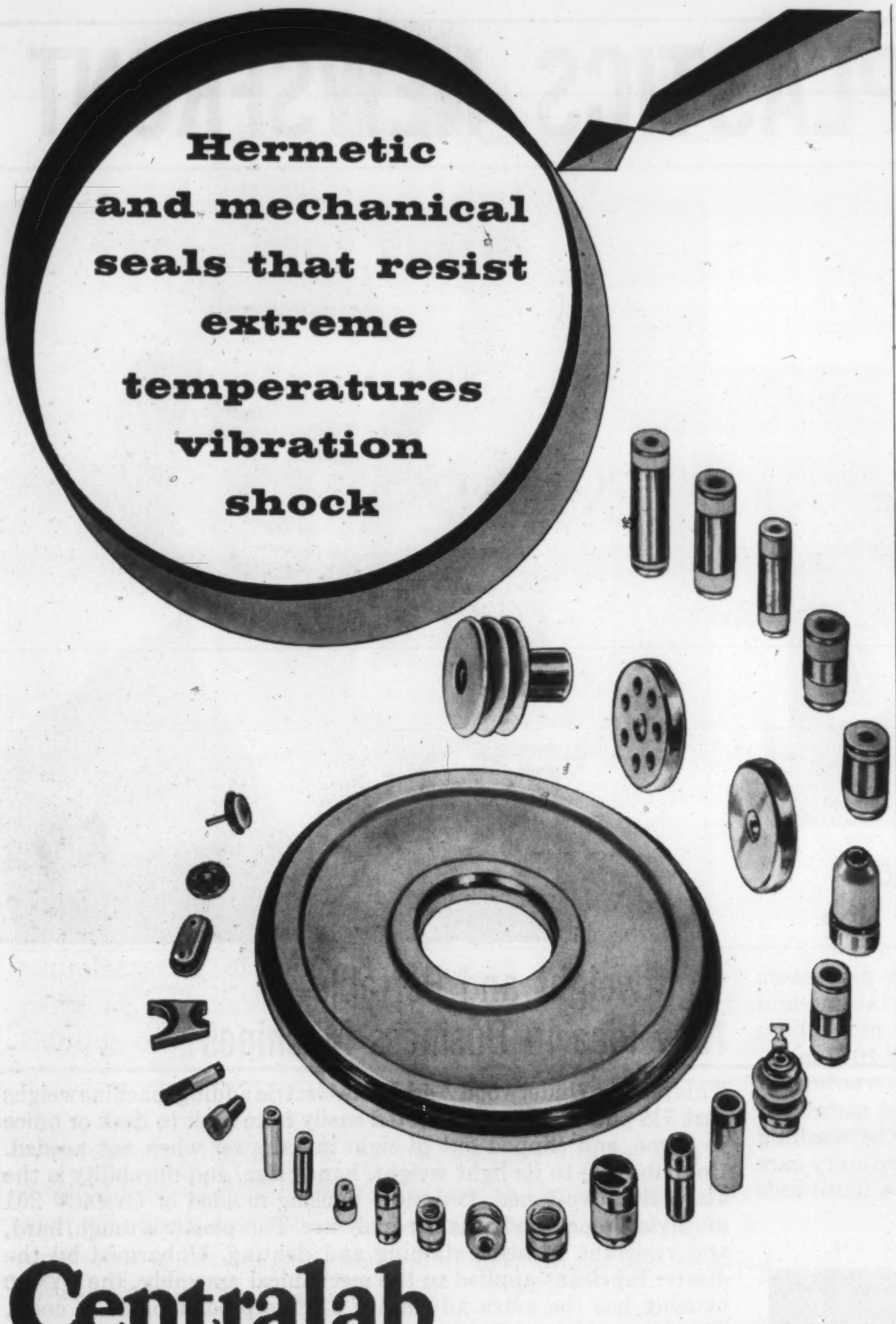
Break-resistant, glass-clear droppers that can be boil-sterilized are among the growing number of products being made of versatile CYMAC 201 methylstyrene-acrylonitrile copolymer. Plastic Assembled Products, Inc. produces pipettes in sizes from 1½ inches to 3½ inches on high-speed injection molding machines, twenty-four units at a time. Dropper closures, in every color for quick product identification, are molded of Cyanamid's BEETLE® urea molding compound.

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
34M Rockefeller Plaza, New York 20, N. Y.

CYANAMID Plastics and Resins Division

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices *in:* Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • New York • Oakland • Philadelphia • St. Louis • Seattle

For more information, turn to Reader Service card, circle No. 431



Centralab

metalized high alumina ceramics

Exceptional metal-ceramic bond strength (withstands 4000 psi pull) combined with the outstanding physical and electrical stability of Centralab High Alumina—results in a product that can provide the solution to many of your military and commercial reliability problems.

Centralab's 30 years' experience in engineered ceramics, plus newly expanded production facilities, provide a fast, dependable source for High Alumina and Steatite ceramics. These can be supplied with or without metalized surfaces.

Write for the new Centralab Engineered Ceramic Design Catalog 42-221 or consult Sweet's Product Design File (folio 4 a/ce).

Centralab

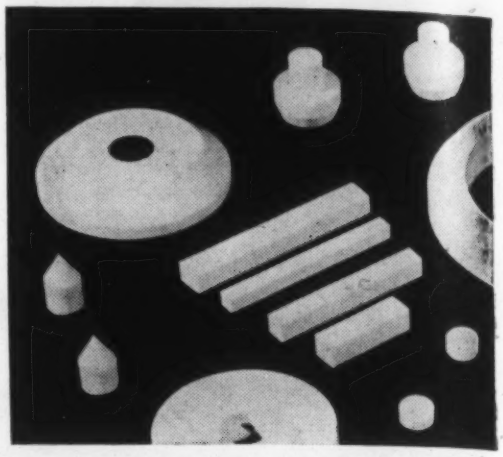
A DIVISION OF GLOBE-UNION, INC.
946J E. KEEFE AVE. • MILWAUKEE 1, WIS
In Canada: 804 Mt. Pleasant Rd. • Toronto, Ontario

X-5821

VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

For more information, turn to Reader Service card, circle No. 365

What's new IN MATERIALS



Furnace parts, *appliance insulators, missile and aircraft parts, tooling jigs, and arc welding nozzles are some of the uses for Duramic Product's new ceramic parts.*

in length. As-fired tolerances of 0.005 in. are possible and the fired parts can be ground to tolerances as close as ± 0.0001 in.

Alkyd Moldings

Moldings produced from a new general purpose alkyd compound reinforced with glass fibers are now commercially available from Panelyte Div., St. Regis Paper Co., 150 E. 42nd St., New York 17.

Parts made from the molding compound, called Stralkyd, are said to have good heat and flame resistance, low water absorption, good mechanical and electrical properties, and good arc resistance. Other properties include good surface appearance, permanent color, high impact strength, rigidity and light weight.

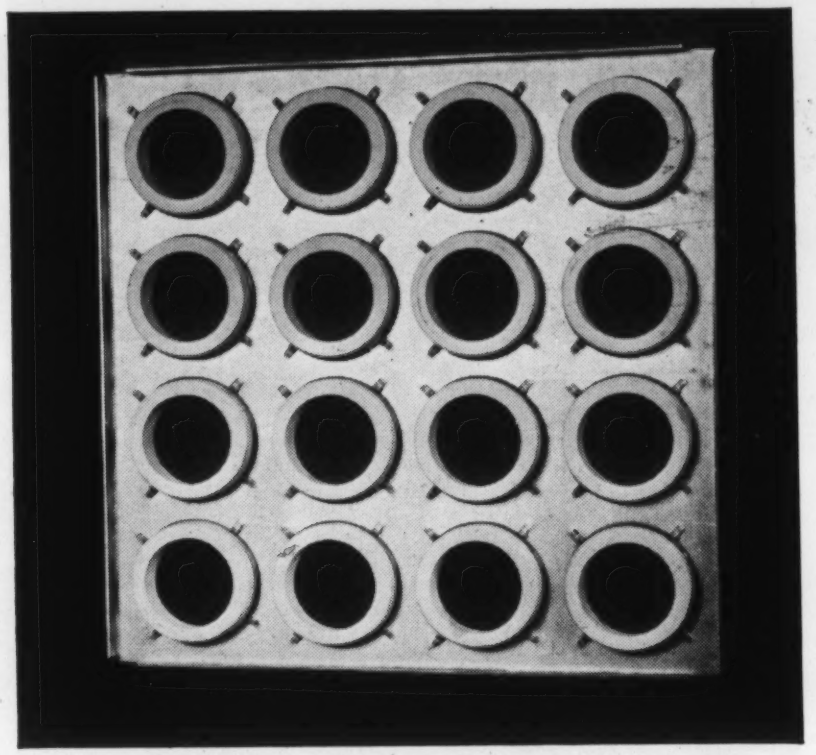
According to the producer, the material is particularly useful in radio and television cabinets, small appliance housings and switch gear moldings.

The moldings are produced at the company's Dexter, Mich. and Trenton, N. J. plants.

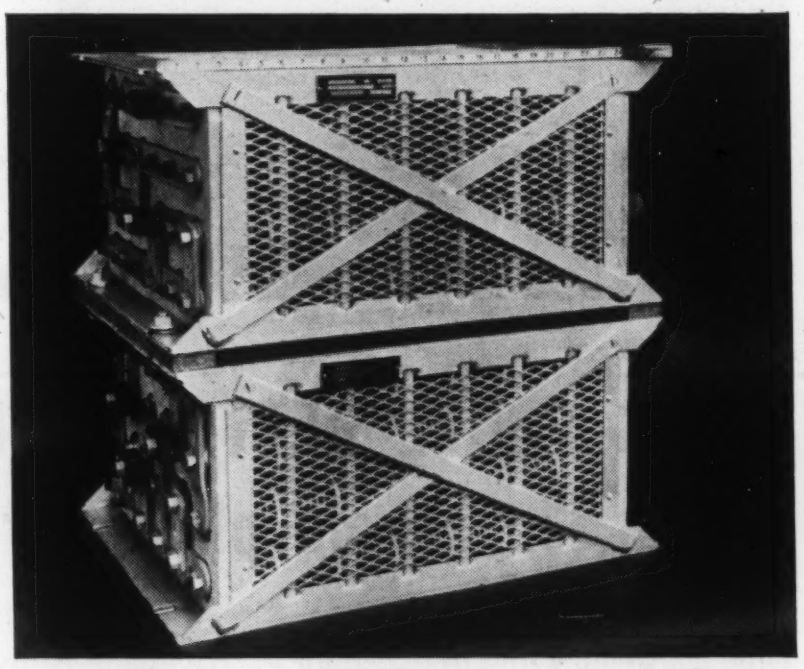
PROPERTIES OF STRALKYD

Notched Izod Impact Strength, ft-lb/in.	1.60
Flexural Strength, psi	13,500
Barcol Hardness	60
Water Absorption, %	0.15
Heat Distortion Temp, F	350
Specific Gravity	2.18
Arc Resistance, sec	180
Dissipation Factor (60 cycles)	0.017

How Armco ALUMINIZED STEEL Helps Electrical Resistors Fight Heat



These high-temperature electrical resistors get **hot.** So every resistor part must resist heat. That's why Armco ALUMINIZED STEEL replaced aluminum-painted carbon steel for coil supports.



A leading manufacturer of electrical resistors for mine locomotives and mill cranes formerly made coil supports from carbon steel protected with aluminum paint. At high temperatures the paint flaked off, causing resistors to fail.

But such premature failures ended when the manufacturer switched to Armco ALUMINIZED STEEL for coil supports. The reason is the *hot-dip coating of aluminum* on ALUMINIZED STEEL. It alloys with the steel base... forms a refractory layer that doesn't flake off at temperatures up to 1250 F.

If heat, or a combination of heat and corrosion, cuts service life of your products, Armco ALUMINIZED STEEL Type 1 offers you this same positive protection. Just fill in and mail the coupon or contact your nearest Armco Sales Office for full information.

Other Armco Steels for top-quality products include ALUMINIZED STEEL Type 2, Stainless Steels, ZINCGRIP®, ZINCGRIP PAINTGRIP®, Cold-Rolled PAINTGRIP, Enameling Iron, Electrical Steels, Steel Tubing, Long Ternes, and high-quality Hot- and Cold-Rolled Sheets.

ARMCO STEEL CORPORATION
1508 Curtis Street, Middletown, Ohio

PLEASE SEND complete information about Armco ALUMINIZED STEEL Type 1. We make_____

NAME_____ TITLE_____

FIRM_____

STREET_____

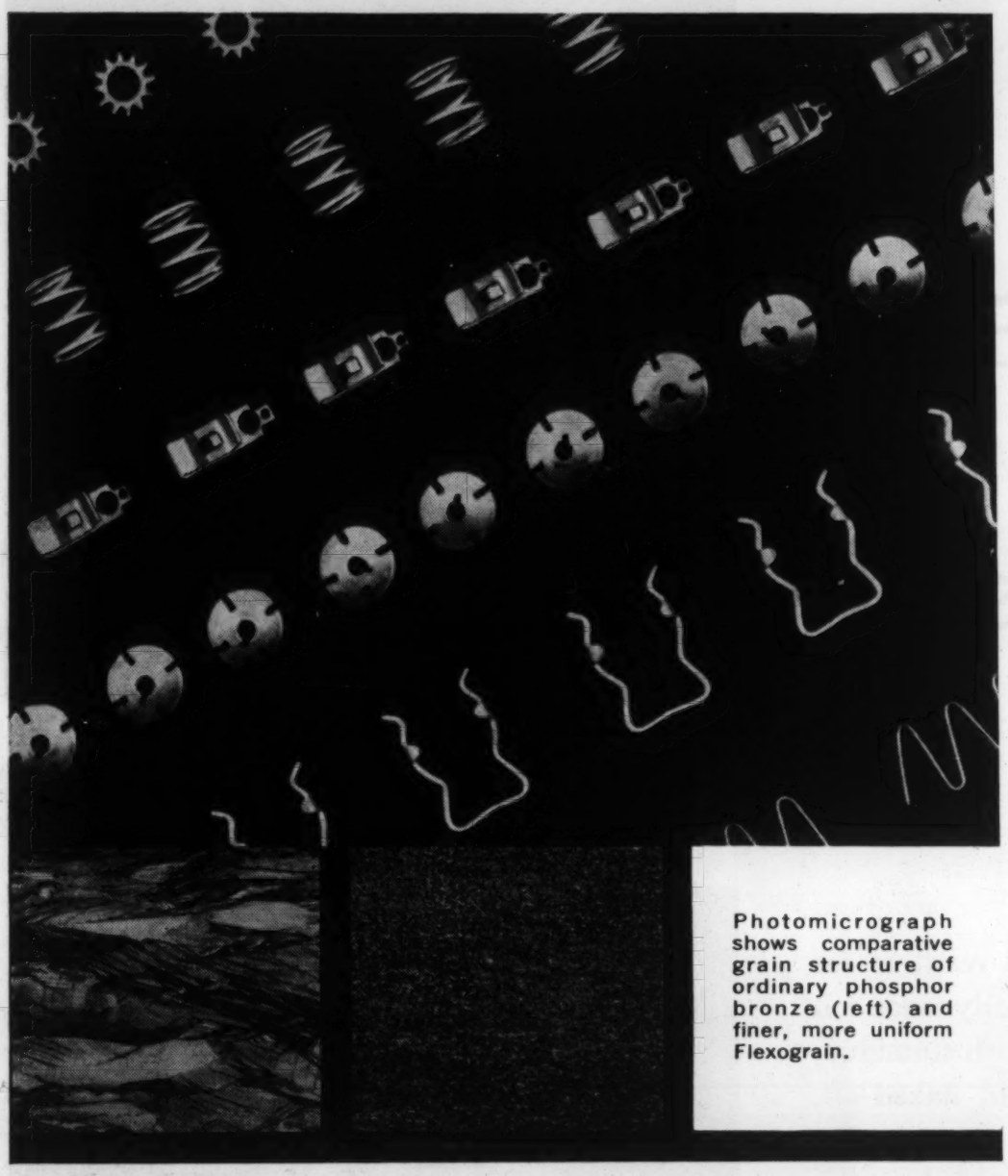
CITY_____ ZONE____ STATE_____

ARMCO STEEL

ARMCO STEEL CORPORATION • 1508 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

For more information, turn to Reader Service card, circle No. 403



Photomicrograph shows comparative grain structure of ordinary phosphor bronze (left) and finer, more uniform Flexograin.

TESTS PROVE BETTER FATIGUE LIFE with Flexograin phosphor bronze

Only a specialty mill in phosphor bronze could produce a product like Flexograin—a uniform, fine-grain phosphor bronze with substantially better fatigue life. Tests prove that Flexograin withstands stress and strain that would cause failure in ordinary, coarse-grain phosphor bronze. Even after torturous forming operations, Flexograin, with its higher ductility, maintains its smooth, bright surface finish.

Riverside-Alloy technical experts don't just accommodate phosphor bronze inquiries—they *concentrate* on them. Chances are, they can suggest new uses for Flexograin that will save you money. Wire, write, or call for complete details. And for free technical bulletin, T-4, which describes the properties and uses of Flexograin, write today to—*Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N.J.*

H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

For more information, turn to Reader Service card, circle No. 389

What's new IN MATERIALS

Other News . . .

Ferrous metals

▸ A low cost grade of preplated steel has been added to the line of preplated metals available from American Nickeloid Co., 2nd & West Sts., Peru, Ill. The metal, available in sheets, coils and strips, can be supplied in chromium, nickel and copper finishes.

▸ Three new patterns of expanded cold drawn carbon steel are available from U. S. Gypsum Corp., 300 W. Adams St., Chicago 6. The patterns—Cathedral, Armorweave and Festoon—are supplied in standard sheet sizes and in sizes to fit customer specifications. The Armorweave and Festoon patterns consist of large, 1½ in. wide mesh openings.

Nonferrous metals

▸ Refinements in production techniques have enabled Electro Metallurgical Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17 to increase the purity of its columbium metal to 99.6%. The metal is supplied in small cylindrical shapes, and in ingots, both machined and as-cast.

▸ Quartz tubing with square, triangular, hexagonal, and other noncircular cross sections has been introduced by General Electric Co., Lamp Glass Dept., Nela Park, Cleveland 12. According to GE, special shapes can be made to customer specifications, with maximum circumferences up to 2 in. per side on a square.

Plastics and rubber

▸ Large-diameter reinforced plastics rods and tubes in sizes up to 8 ft long and in diameters up to 8 in. are being produced by Plasteco, Inc., P. O. Box 9123, Houston, Tex. The rods and tubes are made of epoxy, polyester, phenolic and diallyl phthalate resins reinforced with glass, cotton, Dacron, nylon, Orlon and paper.

▸ A paper-base phenolic laminate, designated as Grade 320, has been introduced by Taylor Fibre Co., Norristown, Pa. The laminate is said to retain its good electrical characteristics after prolonged exposure to high humidity.

(more News on p 172)

How USS Shelby Seamless Tubing improves the design of this portable drilling rig

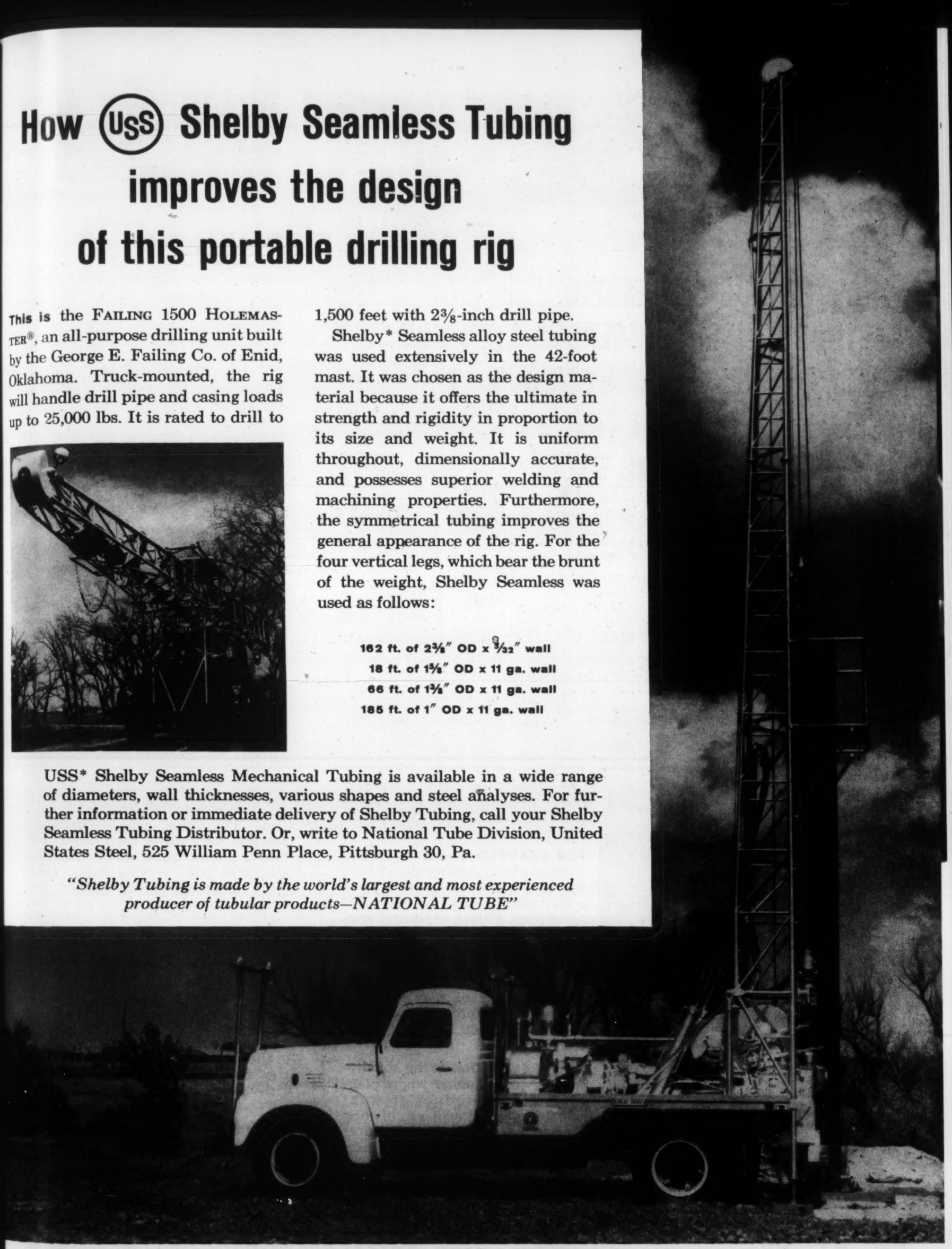
This is the FAILING 1500 HOLEMASTER®, an all-purpose drilling unit built by the George E. Failing Co. of Enid, Oklahoma. Truck-mounted, the rig will handle drill pipe and casing loads up to 25,000 lbs. It is rated to drill to 1,500 feet with 2⅜-inch drill pipe.

Shelby* Seamless alloy steel tubing was used extensively in the 42-foot mast. It was chosen as the design material because it offers the ultimate in strength and rigidity in proportion to its size and weight. It is uniform throughout, dimensionally accurate, and possesses superior welding and machining properties. Furthermore, the symmetrical tubing improves the general appearance of the rig. For the four vertical legs, which bear the brunt of the weight, Shelby Seamless was used as follows:

162 ft. of 2⅜" OD x 9/32" wall
18 ft. of 1⅝" OD x 11 ga. wall
66 ft. of 1⅜" OD x 11 ga. wall
185 ft. of 1" OD x 11 ga. wall

USS* Shelby Seamless Mechanical Tubing is available in a wide range of diameters, wall thicknesses, various shapes and steel analyses. For further information or immediate delivery of Shelby Tubing, call your Shelby Seamless Tubing Distributor. Or, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

"Shelby Tubing is made by the world's largest and most experienced producer of tubular products—NATIONAL TUBE"



National Tube Division of USS United States Steel

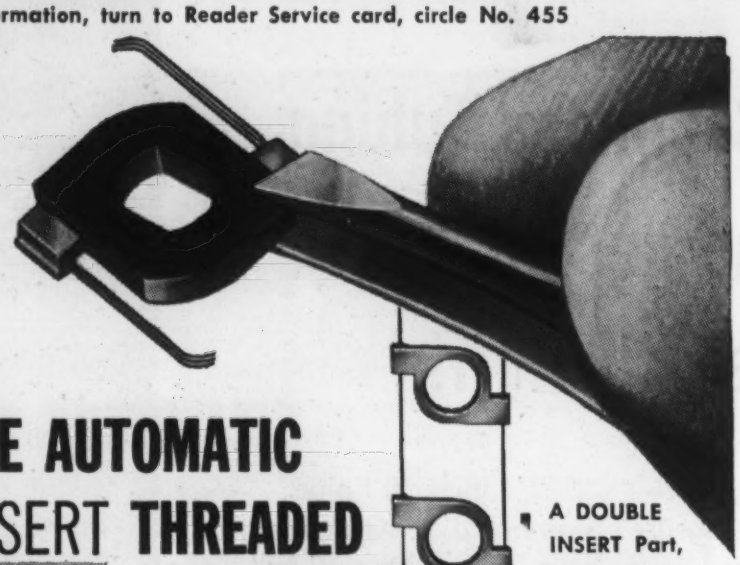
*TRADEMARK

For more information, circle No. 381

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Supply Division • United States Steel Export Company, New York

For more information, turn to Reader Service card, circle No. 455

another wonderful **GRC idea** for designers



GRC's UNIQUE AUTOMATIC METHODS INSERT THREADED PIECES, WIRES, even CONTINUOUS ELEMENTS, RIGHT IN THE MOLDING OR CASTING CYCLE

A DOUBLE INSERT Part, automatically produced

For this IBM Brush Assembly, the core is die cast automatically and continuously onto 6 strands of music wire, 3 on each side.

In the second cycle the nylon insulating jacket is molded automatically and continuously . . . right onto the die cast core and wire inserts.

Fast . . . economical, GRC's exclusive automatic machines insert elements in zinc alloy die castings . . . in thermoplastic molding, assure uniformity, eliminate assembly . . . make possible entirely new designs . . . cut labor and costs

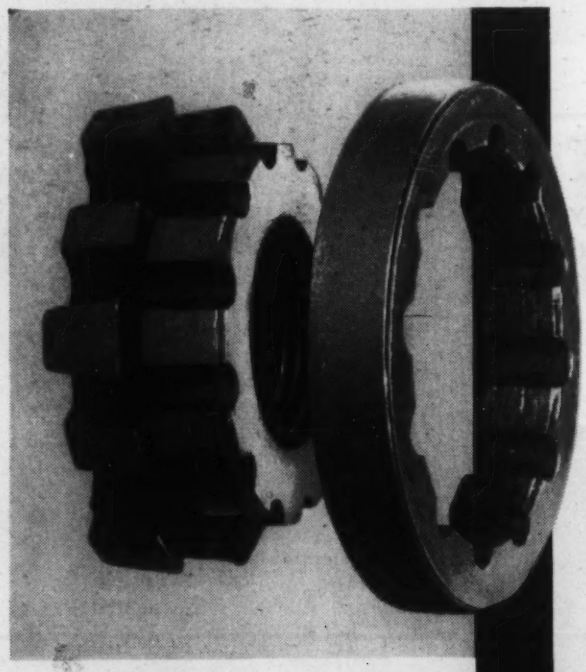
Write for bulletins, send prints for quotation.
No size is too small! Maximums:
Zinc Alloy 1½", ½oz. Plastic 1¼", .03 oz.

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

153 Beechwood Ave., New Rochelle, N. Y. • NEw Rochelle 3-8600

GRIES



IDEA TO FINISHED FORGING

Porter helps you cut costs, improve products

PORTER does more for you than just manufacture fine forgings. Porter provides planning and design assistance to meet your special requirements.

FOR EXAMPLE: The Pre-stressed Concrete Wire Anchor shown here was little more than an idea when a customer came to Porter for assistance. Porter engineers analyzed the idea...redesigned the wire anchor...made and tested models... submitted blueprints for approval ...made dies...and now is producing thousands of wire anchors, carefully drop forging, machining, heat treating and inspecting each component.

YOU ARE WELCOME to this step-by-step service. Whether you're planning a new product or want improvements in an established product or production technique, Porter sales engineers can help you. Write or telephone: Cleveland Forge Works, Forge and Fittings Division, H. K. Porter Company, Inc., Cleveland 4, Ohio.

H. K. PORTER COMPANY, INC.

FORGE AND FITTINGS DIVISION

For more information, turn to Reader Service card, circle No. 495

What's new IN MATERIALS

Other nonmetallics

▸ Colored wool tapes, dots and washers are now available from J. B. Dawn Products Co., 3905 W. 64th Pl., Chicago. The felt has a pressure sensitive adhesive backing that sticks to metallic and nonmetallic surfaces.

▸ A ceramic insulating material designed for electrical heating equipment, such as ranges, broilers and immersion heaters, is now available from Star Porcelain Co., 34 Muirhead Ave., Trenton 9, N. J. The smooth, glazed surface of the insulation, called Thermolain, is said to render it impervious to cooking oils and greases.

Finishes

▸ Two new additions to a family of thermosetting acrylic baking enamels known as Duracron 100 have been announced by Pittsburgh Plate Glass Co., Industrial Finishes Sales Div., 632 Fort Duquesne Blvd., Pittsburgh 22. The new additions, Duracron 200 and 300 resins, are recommended for interior use only; Duracron 100 is satisfactory for both exterior and interior applications.

▸ A new surface finish for type 430 stainless steel has been announced by Armco Steel Corp., Middletown, Ohio. The finish, called Softone, is suitable for built-in oven doors, wall heater panels, home and commercial appliance trim, serving carts, aquarium frames, switch plates and architectural trim.

Joining materials

▸ A water-base plastics adhesive called Vinylstix is now available from Adhesive Products Corp., 1660 Boone Ave., New York 60 for bonding vinyl to wood, metal, paper, cork and other surfaces. According to the producer, the adhesive eliminates fire hazards often encountered with solvent-type adhesives.

Testing equipment

▸ Nondestructive inspection of a part contour, such as the cross section of a turbine blade, is now possible with a device called Contour Transcriber No. 8-18. Developed by Optical Gaging Products, Inc., 26 Forbes St., Rochester 11, N. Y., the unit makes a permanent contour record of master patterns, models, dies and molds on specially coated glass plates.

HOW THE SILICONES MAN HELPED...

CHANGE THE TUNE OF A MACH 5 WHISTLE

Ram a wind thirty-six hundred miles an hour down a wind tunnel 20 inches square. Problems in testing models of supersonic rockets and missiles in such a tunnel gave new dimensions to operational techniques.

Developed by engineers of the Jet Propulsion Laboratory at California Institute of Technology, this advanced wind tunnel presented many unique problems. In order to control the air going into the test section, movable plates were used to vary the area of the opening. The plates, moving against one another, had to be sealed. The abrasion created by this movement destroyed ordinary sealing materials. That is, until UNION CARBIDE Silicone Rubber was used. Fabricated by Reeves Rubber, Inc., of San Clemente, California, in solid strips . . . in hollow tubing that is pressurized for an extra tight fit . . . this silicone rubber performed exceptional service under almost "impossible" conditions. In fact, tests indicate that maintenance will only be required once every two or three years!

This is another example of how the UNION CARBIDE Silicones Man has helped solve an "impossible" problem. A booklet—"Look to UNION CARBIDE for Silicones" describes silicone rubber and many other silicone products. Write Box IM-9704 today. Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

The term "Union Carbide" is a registered trade-mark of UCC.
In Canada: Bakelite Company, Division of
Union Carbide Canada Limited, Toronto 7, Ontario.

UNION CARBIDE
TRADE-MARK

SILICONES

For more information, circle No. 482

WHAT'S YOUR WOOD PROBLEM?

Gamble research lengthens industrial floor life up to 10 times

THE PROBLEM. Ordinary industrial wood block flooring was proving a costly maintenance headache in plants where certain floor areas — loading docks, aisleways, intersections — were subject to heavy traffic loads. Flooring in these areas was rapidly breaking up.

THE RESULT of Gamble testing and development: a laminated end-grain hickory flooring specially made for these heavy-load "hot spots". Gamble engineered flooring lasts up to 10 times longer when subjected to day-in, day-out punishing loads that would quickly break up an ordinary floor. Chances are, Gamble could help with *your* wood problem.

Send for FREE booklet Illustrating GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Bros., Inc., 4627 Allmond Ave., Louisville 9, Ky.

GAMBLE BROTHERS
Incorporated
Louisville 9, Kentucky
If the problem involves WOOD —GAMBLE can help!

For more information, circle No. 408

MATERIALS AT WORK

Pumps—cont'd from p 12

petroleum oil, gasoline, and mineral and vegetable oils; good resistance to weak and strong acids and alkalis.

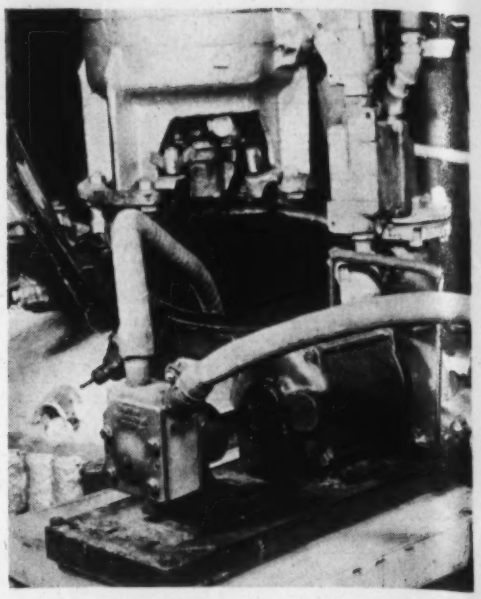
Compar—Extremely resistant to organic solvents; attacked by water, weak acids and alkalis.

Hypalon—Exceptional resistance to strong oxidizing acids; excellent resistance to dilute and concentrated acids, and weak and strong alkalis; good resistance to concentrated mineral acids.

Kel-F Elastomer—Excellent resistance to strong oxidizing acids, mineral acids, peroxides, alkalis, alcohols, aliphatic solvents and hydraulic fluids; excellent heat resistance.

Silicone—Resistant to weak acids and alkalis.

Butyl—Outstanding resistance to dilute mineral acids; excellent resistance to vegetable and mineral oils and solvents such as acetone, alcohol, phenol and ethylene glycol; excellent heat resistance and low gas permeation.



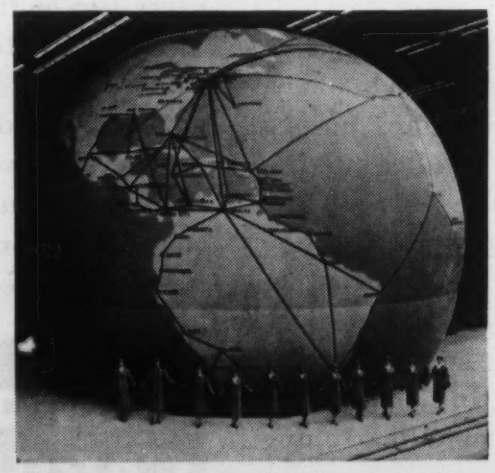
***Acid pump** for 30% cold hydrochloric uses polyethylene body block and Hypalon flexible liner.*

Aluminum Plates Used for Drivers' Licenses

Thanks to imaginative use of photosensitive anodized aluminum plates, automobile owners (and policemen) in South Carolina are no longer plagued with torn, wrinkled, illegible drivers' licenses. The anodized aluminum plates (see photo on p 176) are neat, lightweight, legible, durable and smudgeproof. They have rounded corners and a punched hole for attachment to a key retainer.

The plates are easily processed by standard photographic techniques. First step is to photograph 36 license applications on a single negative. The film is developed in the standard manner, placed in contact with the photosensitive aluminum sheets and exposed to light. Standard photographic techniques are used to develop the plates. The developed sheet is then cut into the individual licenses, the corners rounded and the retainer hole punched.

According to Metalphoto Corp., manufacturers of the aluminum

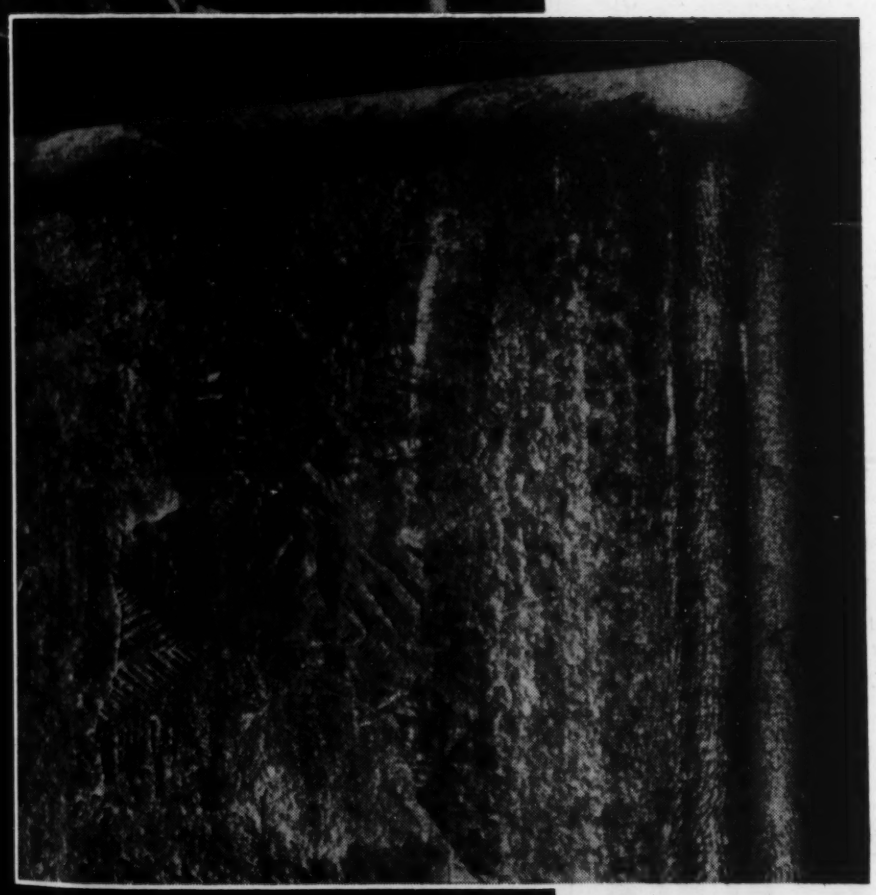


A world of nylon—The slightly oversized "balloon" shown in the accompanying photo is actually a portable planetarium made from 1000 yd of vinyl-coated nylon fabric filled with 70,000 cu ft of air. According to U.S. Rubber Co., the structure is 52 ft in dia and 42 ft high, and seats more than 150 persons. When deflated, however, the unit can be packed in an 8 x 6 x 6-ft box. It was developed to be a part of the U. S. exhibit at the Brussels World's Fair.

Handkerchief fold

on USS Galvanized Steel Sheets

proves the zinc stays on



These are unretouched pictures of twice-folded USS Galvanized Steel Sheets. The sheet in the smaller picture is magnified three times actual size.

We cut a piece from a sheet of USS Galvanized Steel—bent it double—
then we bent it double again.

But look at the zinc coating along the outside of the bend. Not one bit of the coating flaked off! What's more, we restraightened the sheet and still not one speck of zinc came loose!

This kind of adherence means you can fabricate USS Galvanized Steel Sheets in ways you may not have thought possible.

Unless otherwise ordered, USS Galvanized Sheets are chemically treated to inhibit the formation of white oxide—sometimes called humid storage stain.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
American Steel & Wire – Cleveland
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel

USS
TRADEMARK

No SPECIAL HANDLING REQUESTED

This means new business for somebody. It could be you.

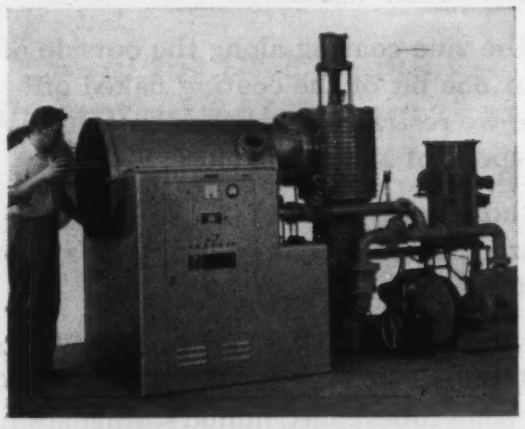
Because vacuum-metallized pieces now can "take it," thousands of products will, for the first time, be finished this new way.

More durable lacquers now protect the superb finishes only vacuum metallizing can produce at low cost. New lacquers and resins now stand up to rigorous abrasion tests and exposure to salt spray and high humidity.

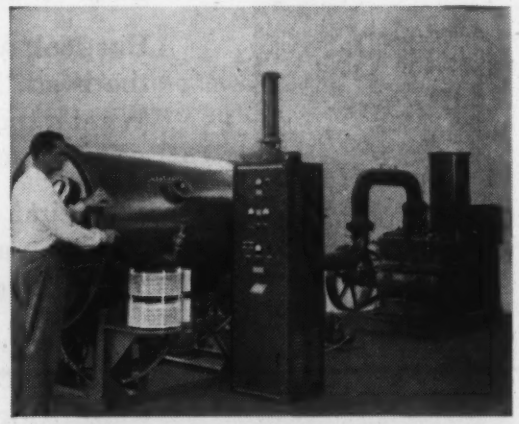
Vacuum metallizing is sure to grow rapidly. New business is waiting for you.

At CEC, we are ready to help you with a full range of vacuum coaters, headed by a large 72" model for metallizing large pieces fast and at low cost.

We'll be glad to send you bulletins on our line of coaters, and share our experience in helping you set up operations.



30" coater—model LC1-30
Typical production: 400 1½" diameter pieces per cycle; 5 to 7 cycles per hour.



48" coater—model LC1-48C
Typical production: 1450 2½" diameter pieces per cycle; 3 to 6 cycles per hour.

Smaller coaters are available for production coating of optics or other small parts, and for laboratory and pilot plant work.

Consolidated Electrodynamics
Rochester Division, Rochester 3, N. Y.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service card, circle No. 413

MATERIALS AT WORK

License is photographed *on photosensitive anodized aluminum plates.*

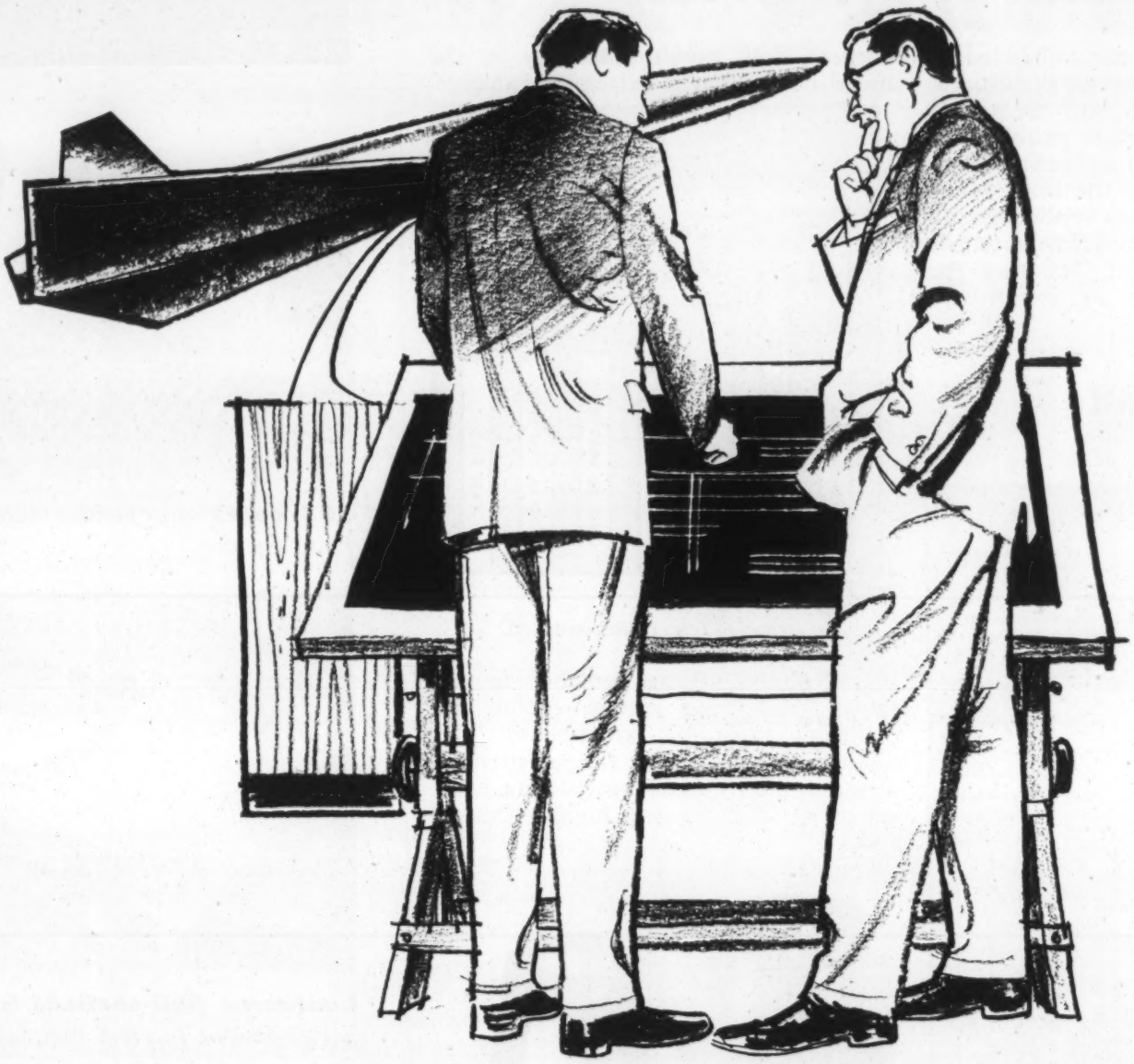
plates, the photosensitive element is embedded below the surface and the sapphire-hard aluminum oxide coating prevents the image from matting. The plates are also said to be impervious to acids, salts and solvents.

Vinyl Foam Cushion Has Molded-In Cores

Reduced labor and materials costs in the production of cored vinyl foam cushions are being achieved as a result of a molding technique de-

Allegheny Ludlum Steel Corp.

Pressure vessel—The thin-walled pressure vessel shown in the accompanying photo is made of a relatively new precipitation hardening stainless steel alloy called AM-350. The vessel will be used in the X-15 rocket research plane, slated to be the first plane to take man into outer space.



WHATEVER YOU REQUIRE IN SILVER

. . . HANDY & HARMAN IS YOUR BEST SOURCE OF SUPPLY

You can go no further for available knowledge of, and experience in, the manufacture of silver and silver alloys. In the ninety years Handy & Harman has been active in the research, manufacture and application of silver and silver alloys for all industry, it has gained the reputation of The Number One Source and Authority.

Among the many forms of silver and silver alloys manufactured by Handy & Harman are:

• Fine silver (wire, strip and foil) • Silver anodes and grain for plating • Silver contact alloys • Silver powders • Silver flake, paints and paste • Silver brazing alloys • Silver electronic solders • Silver sintered metals • Solder-flushed silver alloys • Silver chloride and oxide • Coin silver (wire and strip) • Silver bi-metals

JOIN THE HANDY & HARMAN FREE LIBRARY

We have four Technical Bulletins giving engineering data on the properties and forms of Handy & Harman Silver Alloys. We would like you to have any or all of those that particularly interest you. Your request, by number, will receive prompt attention.

Fine Silver	Bulletin A-1
Silver-Copper Alloys . .	Bulletin A-2
Silver-Magnesium-Nickel	Bulletin A-3
Silver Conductive Coatings	Bulletin A-4

Our Technical Service and field application experience are at your disposal . . . we welcome inquiries on products and product problems involving any form of silver.

Your No. 1 SOURCE OF SUPPLY AND AUTHORITY ON SILVER ALLOYS

HANDY & HARMAN
FOUNDED 1867
QUALITY • SERVICE

HANDY & HARMAN

General Offices:
82 Fulton Street, New York 38, N. Y.

Offices and Plants: Atlanta, Georgia • Bridgeport, Connecticut • Providence, Rhode Island • Chicago, Illinois • Cleveland, Ohio • Detroit, Michigan • Los Angeles, California Oakland, California • Toronto, Canada • Montreal, Canada

For more information, turn to Reader Service Card, circle No. 383

How to Design Economical Parts to Withstand Cyclic Stress

Many machine parts are subjected to repeated stress under service conditions. Cyclic loading of this sort frequently imposes a difficult design problem. A metal cannot withstand a repeatedly applied stress as large as the load which it can stand if that load is applied steadily. Thus fatigue limit, rather than tensile strength, or yield point, becomes the most important factor in design and metal selection.

Fatigue Limit and Fatigue Ratio

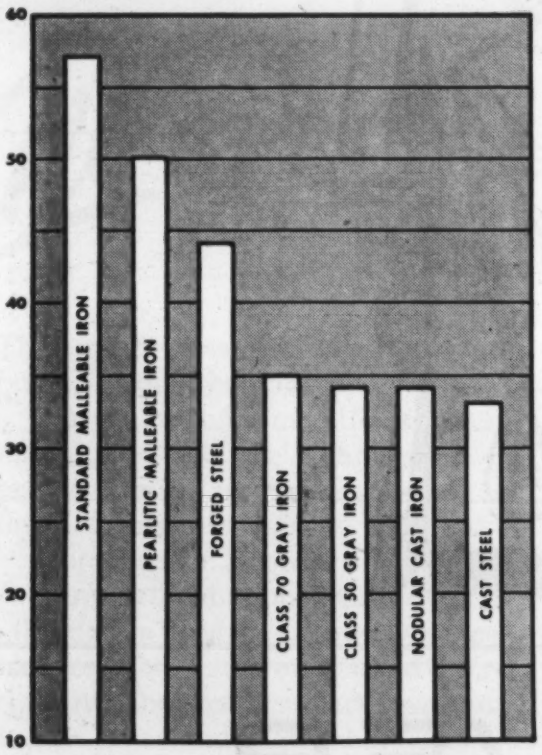


Fig. 1 . . .
Average fatigue ratios, unnotched.

The fatigue limit of a material is the limiting value of the stress below which it can presumably endure an infinite number of stress cycles. Fatigue limit is determined by applying repeated or reversed cycles of stress in tension, compression, transverse loading, or torsion. Most tests are stopped at ten million cycles if failure has not occurred, and the life of the specimen is then said to be indefinite.

The fatigue or endurance ratios (ratio of fatigue limit to tensile strength) of various metals are shown in Fig. 1. As indicated, the susceptibility of both ferritic and pearlitic malleable irons to progressive fracture is much less than in many other metals. This is attributable to the ferritic matrix which so completely envelopes the temper carbon nodules in the structure.

Fatigue Characteristics Under Notch Conditions

Whenever design requirements involve radical section changes or sharp internal corners, low notch sensitivity in the metal being used is extremely valuable.

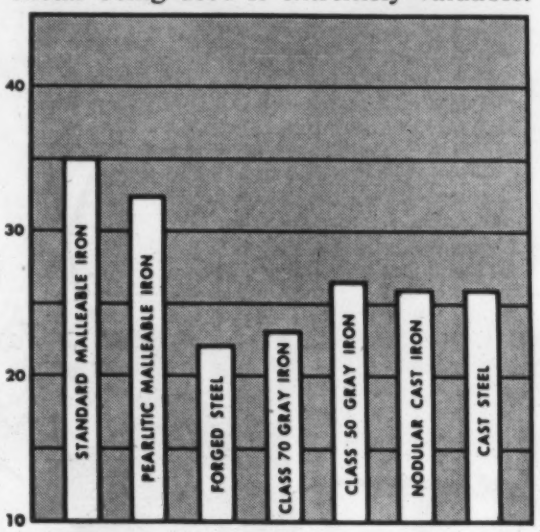


Fig. 2 . . .
Average fatigue ratios, notched.

Fig. 2 shows average notched fatigue ratios for various metals. Again, the malleable irons are far superior. The fatigue ratio and notch fatigue strength of malleable iron castings become even better by shot peening highly stressed areas.

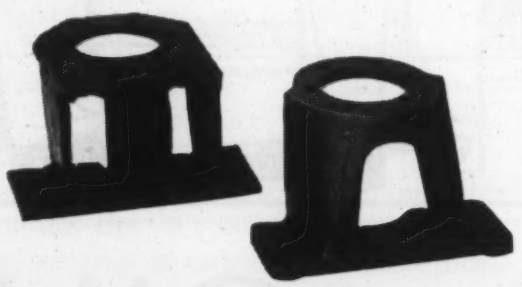


Fig. 3 . . .
Example of high fatigue resistance.

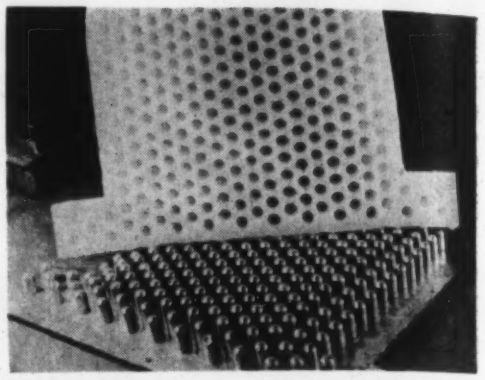
Good use of malleable's excellent fatigue strength is illustrated in this pump mounting bracket for an agricultural sprayer. The pump is bolted on the top and the drive shaft runs through the large center hole causing continuous cyclic loading. Conversion from a five part weldment with drilled holes to a malleable casting resulted in an increase in fatigue resistance at lower cost. Other advantages are better appearance, elimination of machining and a weight reduction of 22%.

Malleable iron's superior fatigue resistance is just one of the many excellent qualities that help you do a better job with malleable.

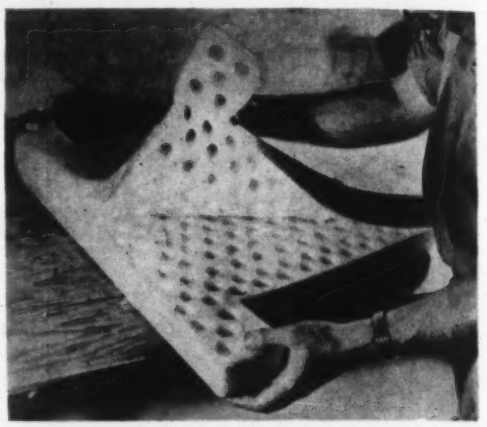
Write for Data Sheet

Comparative information on fatigue characteristics of various metals is available in handy data sheet form for use by design engineers and materials specifiers. For your copy write to **The Malleable Founders Society, 1800 Union Commerce Building, Cleveland 14, Ohio,** or contact any member foundry.

AT WORK



265 cores *are molded into vinyl foam cushion.*



***Contoured half-sections** are adhesive-bonded to form complete unit.*

veloped by Bakelite Co., Div. of Union Carbide Corp.

The major difference between Bakelite's technique and conventional methods is that the cores are molded in, rather than mechanically cut out of slab stock. According to Bakelite, this reduces materials requirements by as much as 50%.

To make the cushions, uncured vinyl foam is injected through nozzles directly into the cushion molds. The molds then pass through a heating unit where the foam is cured in about 25 min. The cushions are molded in two sections which are then adhesive-bonded to each other (see photo).

According to Bakelite, the reversible vinyl cushions resist fire and retain their original shape and dimensions without sagging or lumping, even after long hard use.

WATCH FOR 'SELECTOR'—The second edition of M/DE's *Materials Selector*—revised, expanded and upated—will be published in mid-October, following the regular October issue. The special issue is included in the M/DE subscription.

For more information, turn to Reader Service card, circle No. 470

Get Lower Costs — Better Performance with

GENERAL PLATE

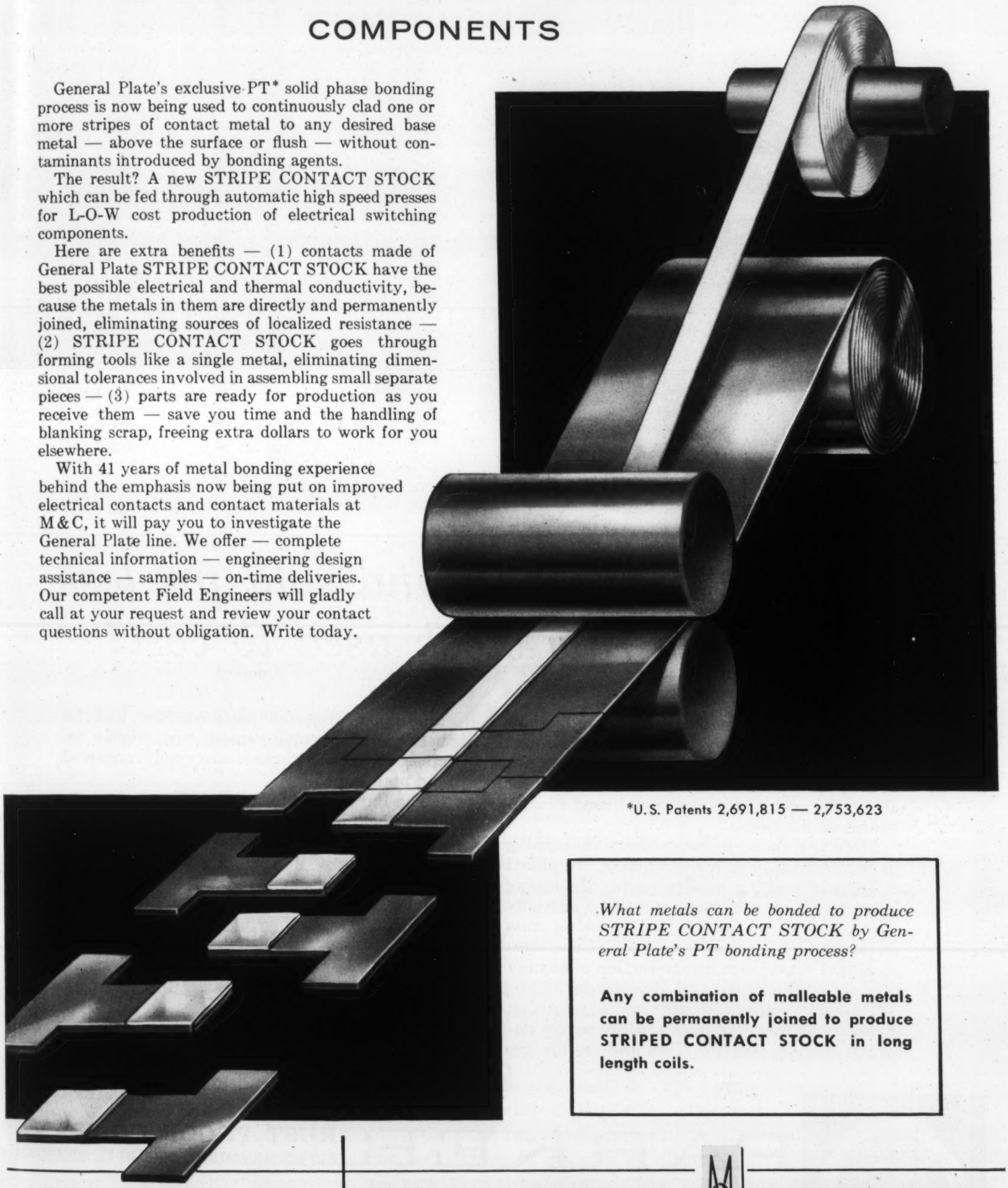
STRIPED CONTACT SWITCHING COMPONENTS

General Plate's exclusive PT* solid phase bonding process is now being used to continuously clad one or more stripes of contact metal to any desired base metal — above the surface or flush — without contaminants introduced by bonding agents.

The result? A new STRIPE CONTACT STOCK which can be fed through automatic high speed presses for L-O-W cost production of electrical switching components.

Here are extra benefits — (1) contacts made of General Plate STRIPE CONTACT STOCK have the best possible electrical and thermal conductivity, because the metals in them are directly and permanently joined, eliminating sources of localized resistance — (2) STRIPE CONTACT STOCK goes through forming tools like a single metal, eliminating dimensional tolerances involved in assembling small separate pieces — (3) parts are ready for production as you receive them — save you time and the handling of blanking scrap, freeing extra dollars to work for you elsewhere.

With 41 years of metal bonding experience behind the emphasis now being put on improved electrical contacts and contact materials at M&C, it will pay you to investigate the General Plate line. We offer — complete technical information — engineering design assistance — samples — on-time deliveries. Our competent Field Engineers will gladly call at your request and review your contact questions without obligation. Write today.



*U.S. Patents 2,691,815 — 2,753,623

What metals can be bonded to produce STRIPE CONTACT STOCK by General Plate's PT bonding process?

Any combination of malleable metals can be permanently joined to produce STRIPED CONTACT STOCK in long length coils.

You Can Profit By Using General Plate Clad Metals.

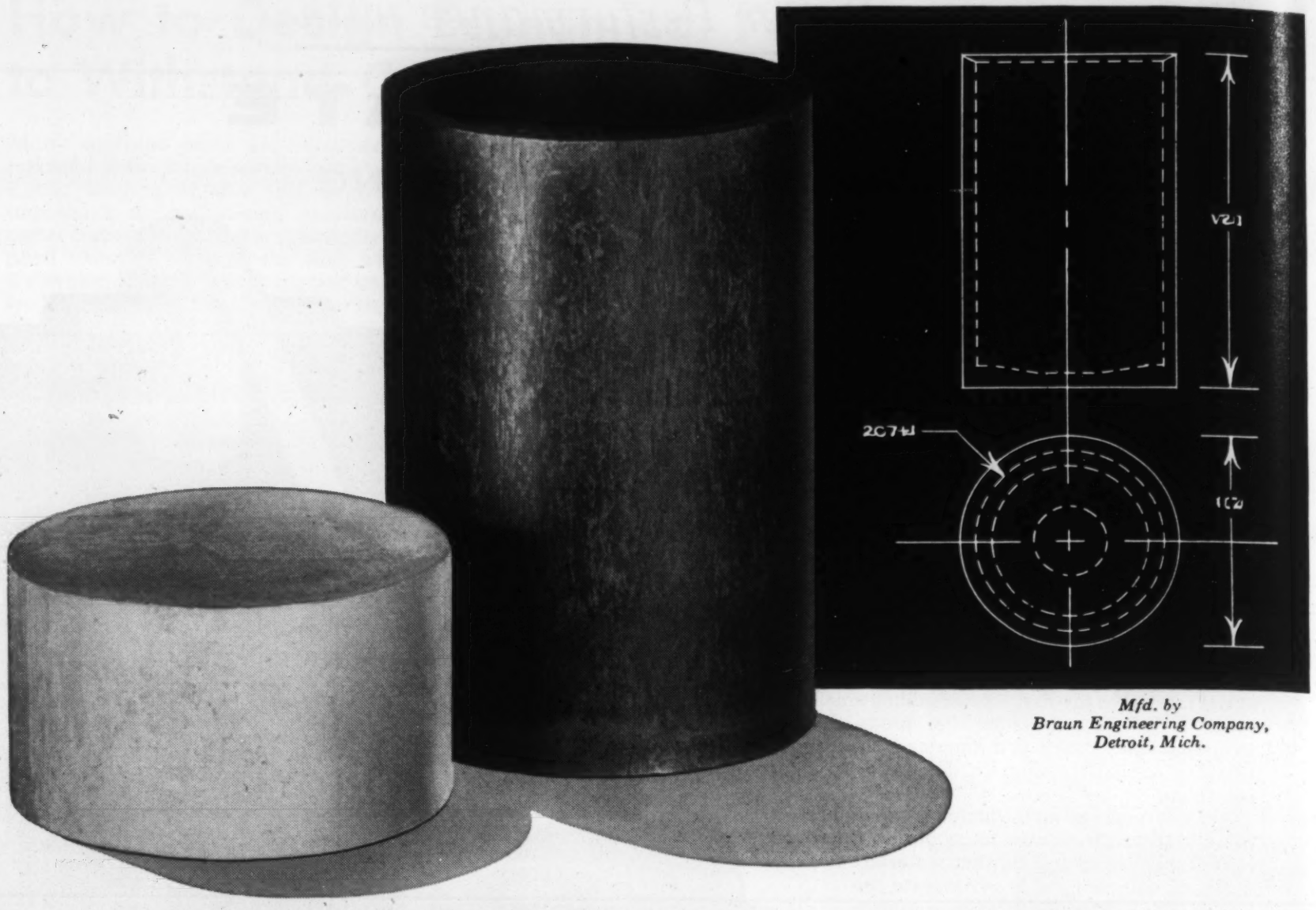
METALS & CONTROLS CORPORATION

General Plate Division

1609 Forest Street, Attleboro, Mass.

FIELD OFFICES. NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

For more information, turn to Reader Service Card, circle No. 392



Mfd. by
Braun Engineering Company,
Detroit, Mich.

EXTRUDED...*and sold for less than the raw stock used to cost!*

Cold extrusion of steel means big reductions in material, machinery, and time. Frequently, as in the case of the automotive motor mount above, the part is made by cold extrusion for about the cost of the raw metal used in conventional methods.

More and more, manufacturers are turning to cold extrusion as a cost cutting, simplified method of making quality parts. Machining is cut to a bare minimum and scrap virtually disappears. "Impossible" jobs are being mass produced at high rates and a lot of the "impossibles" have become production runs only because of Bonderite and Bonderlube.

These two remarkable aids in cold extrusion make metal flow like magic. More severe deformations are possible. Tool and die life are multiplied. Rejected parts are few and far between. Production speeds are greatly increased. Smooth finishes are easily achieved and maintained.

The Parker cold forming staff can give you expert help in the technique of cold extrusion.

THE OLD WAY

THE BONDERITE-BONDERLUBE WAY

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base

BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

TROPICAL heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 461

PRICES AND SUPPLY

...AT A GLANCE

PRODUCTION OF COPPER AND COPPER ALLOY PRODUCTS is slated for a 30 million-pound-per-year increase when American Brass Co.'s new $18 million plant goes into full production in the near future. The new plant, located near Los Angeles, will concentrate primarily on tubing, rod, bar, sheet and strip.

A 10-20% INCREASE IN ASBESTOS PRODUCTION has been scheduled for Canada in spite of the fact that consumption in 1958 is thus far 20% below that of 1957. Increased production will result from American Smelting and Refining Co.'s new 5000-ton-per-day fiber plant and National Gypsum Co.'s new 3000-ton-per-day plant. Reasons given for the reduced consumption: U. S. recession, dollar shortage abroad, and competition from cut-rate Russian asbestos.

HIGH PURITY VANADIUM IS NOW AVAILABLE IN COMMERCIAL QUANTITIES from Vanadium Corp. of America. According to the producer, metal with 99.5% min vanadium content is offered in the form of buttons up to 25 lb, as-cast ingots (2 in. in dia and 5 in. high) up to 3 lb, and machined ingots. Prices start at $40 per lb in quantities of 250 lb; as-cast ingots are $10 more, machined ingots $20 more.

PRODUCTION OF CAPROLACTUM WILL BE INCREASED by about 20 million pounds per year when a new plant, jointly owned by Spencer Chemical Co. and Industrial Rayon Corp., goes on stream early in 1960. Caprolactum is a basic raw material used in the manufacture of nylon plastics.

PLATINUM PRICES HAVE BEEN REDUCED $5 per oz—from $67-70 to $62-65—for the third time this year. The two previous $5 cuts occurred in February and May. Reasons given for the latest reduction are reduced demand and foreign competition. Average price of platinum for the year 1957 was $90.50 per oz.

PRODUCTION OF ALUMINUM during the first half of 1958 was approximately 20% below that of the similar period in 1957. The substantial reduction—from 824,000 to 762,500 tons—was the direct result of voluntary curtailments put into effect as a result of decreased demand for the metal. According to the Aluminum Assn., the aluminum industry is now estimated to be operating at slightly less than 70% of its effective capacity.

Metal users,

you can simplify...

you can save money

by standardizing on

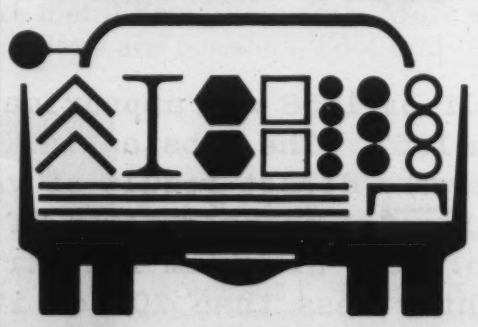
two alloy steels...

4620...4340

easy to get at your

Steel Service Center

AMERICAN STEEL



WAREHOUSE ASS'N.

Standardize on AISI 4620 and 4340 and you standardize on fabricating and heat treating processes...

Simplify inventory and purchasing...

Save money by cutting production costs right down the line...

You standardize, simplify and save money when you use AISI 4620 and 4340...available coast-to-coast from Steel Service Centers. For a list of these sources write:

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO **New York 5, N. Y.**

PRINTED IN U.S.A.

Prices of Materials

Changes since last quarterly report in June are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	.46-**.51**
Butadiene-Styrene	.16- 30	.22-.32
Butyl	.22-.26	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural[b]	**.26**	—

[a]Less than carload quantities.
[b]Average spot price for month of June.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.21-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.40-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.25-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25
Ingot (99-99.9%)	.27
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.28
Sheet (1100, 3003; 3-0.03 in.)[a]	.41-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.42-.45

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.44	.46	.47
Seamless Tubing	.46	.49	.50
Rod (not f.c.)	.44	.46	.47
Wire	.44	.47	.47

COPPER

Ingot (elec)	.26½
Sheet, Strip (hot rolled)	.50
Seamless Tubing	.50
Rod, Drawn	.47
Rod, Free Cutting	.56
Wire	
Round	.32
Square, Rectangular	.35
Magnet	.38

LEAD

Common Grade	.11

MAGNESIUM

Pig (98.8%)	.35-.36
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

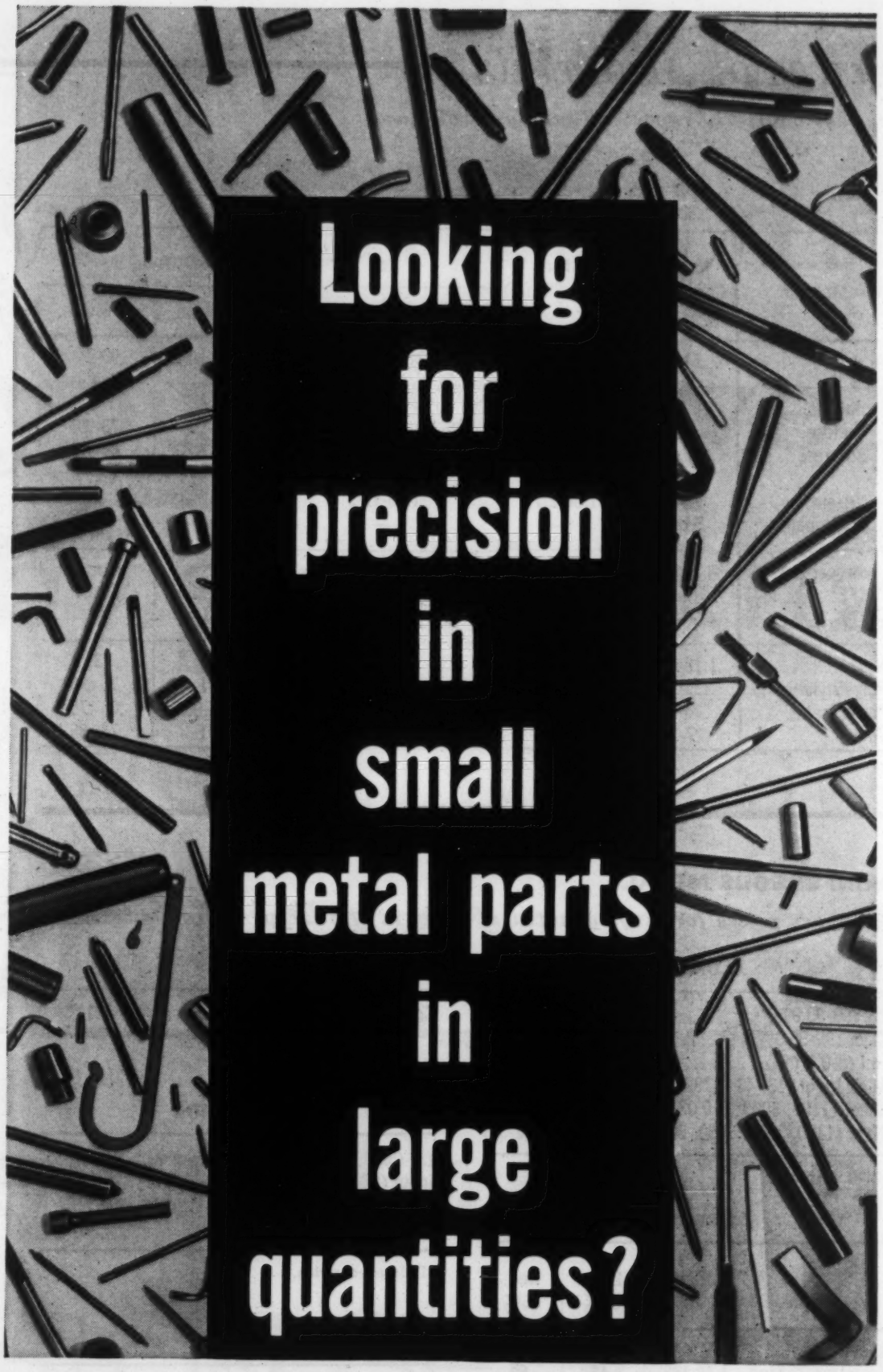
[a]Delivered price.

TIN

Primary[a]	.95

[a]Delivered price.

(continued on p 184)



CALL ON TORRINGTON!

Custom manufacture of small precision metal parts in large volume is the single concern of our Specialties Division. Skilled engineering and modern production facilities insure that parts are made to your most exacting standards . . . by the most economical and efficient methods for your particular job . . . on a reliable production schedule to meet your quantity requirements.

For production in quantity of high-quality precision metal parts, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 777 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

For more information, turn to Reader Service card, circle No. 476

TITANIUM

Sponge (99.3+%)	1.85-2.05
Bars, Rod	5.25-6.35
Plate	6.00-9.50
Sheet, Strip	8.50-15.95
Wire	6.50-11.50

ZINC

Prine Western	.10
Die Casting Alloys[a]	.13
Sheet	.24
Ribbon	.21
Plates	.19

[a]Alloys 2, 3, 5.

METAL POWDERS

Aluminum [a,b]	.40
Brass [a]	.31-.47
Copper (elec or red.)[a]	.41
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.55
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$19-21/troy oz
Platinum	$62-65/troy oz
Silver	89-91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	80
Zirconium (sheet, strip, bar)	25-35

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

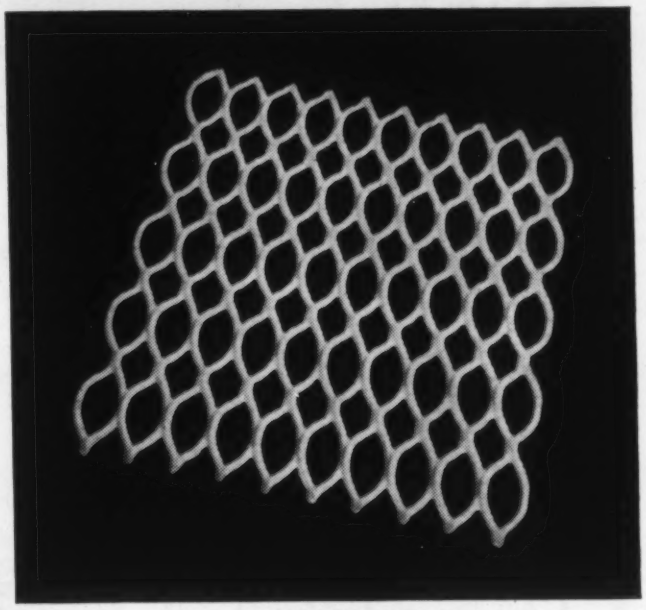
(continued on p 186)

OUTSTANDING NEW QUALITY

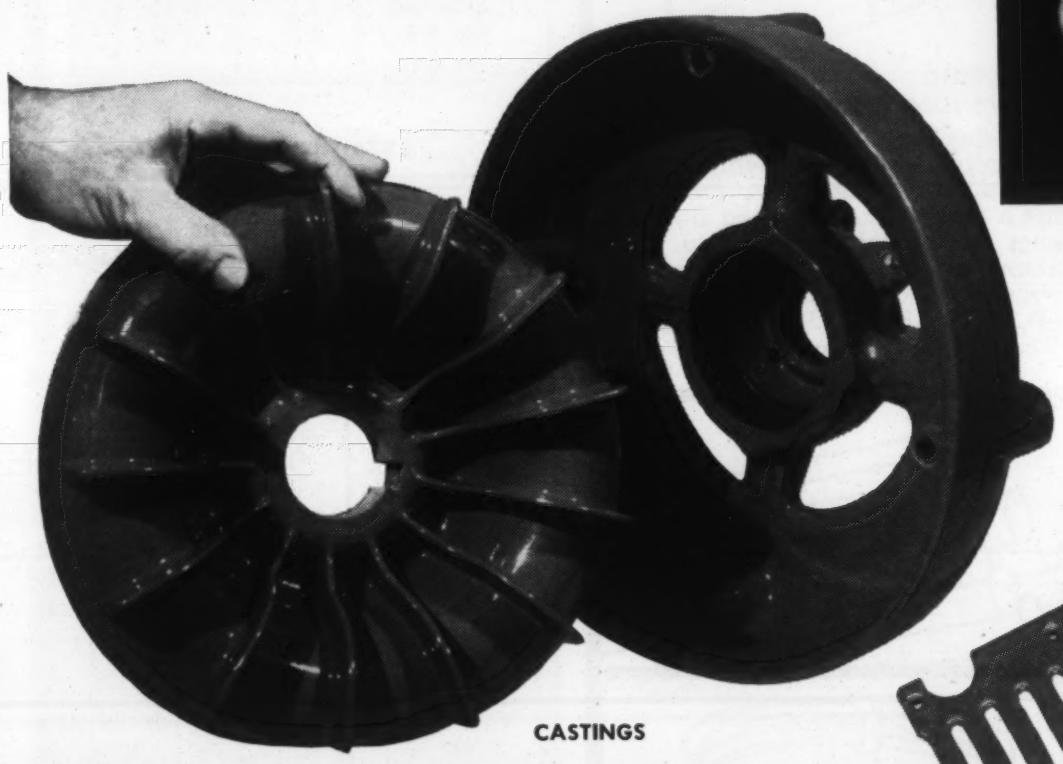
with

CORVEL†

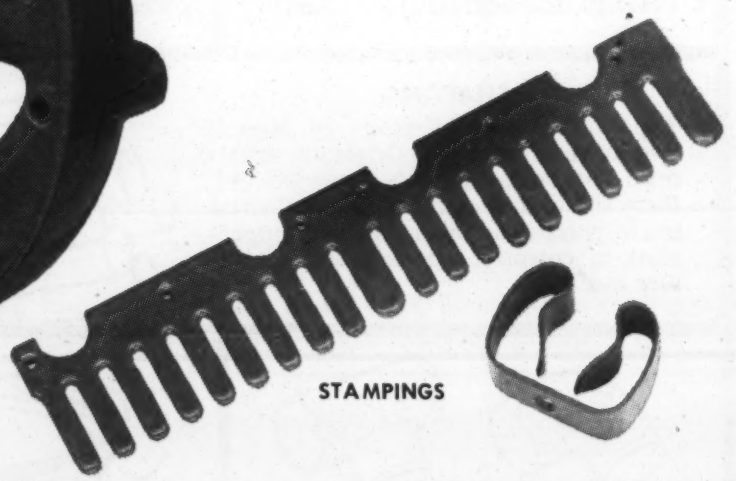
Fusion Bond Finishes



WIRE PRODUCTS



CASTINGS



STAMPINGS

• CORVEL Fusion Bond Finishes, applied by the Whirlclad® Finishing Process, now give these unique product finish advantages:

- Controlled thickness in one dip—from .005″ to .060″.
- Thorough coverage of corners, sharp edges, projections, joints and intersections—without bridging across gaps.
- Good adhesion to substrate surfaces.
- Resistance to corrosion and most chemicals.
- Premium appearance—multiple color selection, controlled sheen.
- Durable color and gloss.
- The RIGHT Finish for YOUR Product.

CORVEL Fusion Bond Finishes are powders specially formulated for use with the Whirlclad* Finishing Process. The part to be finished is first heated, then dipped into a fluidized bed of *dry* CORVEL powder. The powder, maintained in a state of whirling suspension, bonds by fusion on contact with the part.

CORVEL Finishes are now available in Cellulosic, Vinyl, Epoxy, Nylon, Chlorinated Polyether, and Ethylene base resins.

***WHIRLCLAD Finishing Process:**

A new, patented production process for cladding metals and other materials with plastic resins—exclusively licensed in the U.S. and Canada by Polymer Processes, Inc., an affiliate company.

We invite your inquiry for product finish economy and improvement. Write today for our new CORVEL Bulletin.

NATIONAL POLYMER PRODUCTS, INC. / Reading, Pennsylvania

A subsidiary of The Polymer Corporation

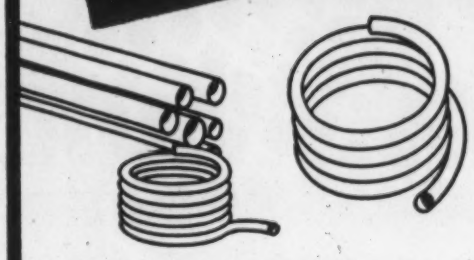
†Polymer Corporation trademark for finishing materials

POLYPENCO®

For more information, turn to Reader Service card, circle No. 521

Series 2

PLUS ITEMS
from your Whitehead Metals "Supermarkets"



PLASTIC PIPE

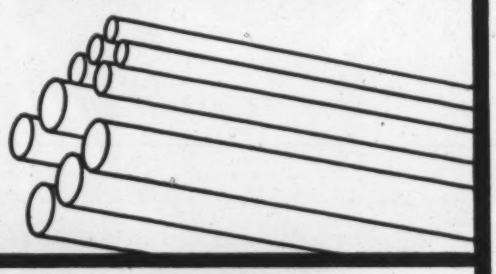
A full line of flexible and rigid plastic pipe and tubing in all commercial resins, in sizes from ⅛" to 4" OD. Fittings, cements and valves available from stock. Write for detailed literature.

NON-SKID ALUMINUM TREAD PLATE

Providing amazing gripping power (either oily or dry) this lightweight, corrosion resistant Alcoa product has a tough abrasive (fused aluminum oxide) rolled right into an aluminum base plate for longer wear. Available in four thicknesses —0.125", 0.188", 0.250" and 0.375" Write for descriptive booklet.

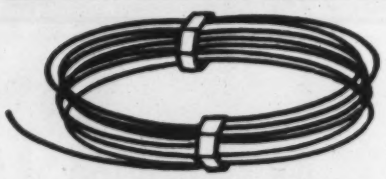
SHAFTING

Top quality shafting made of Monel, Everdur or Tempalloy. Originally developed for boats and other marine use, these shafts have gained wide industrial use in pumps and other machinery operating in corrosive atmospheres. Literature available.



WELDING FITTINGS

Stainless Steel forged welding fittings are stocked in I.P.S. sizes from ½" to 12" for Schedule 5S, 10S, 40S and 80S Pipe. All conventional shapes are on hand. Welding fittings are also stocked in Aluminum, Monel, Nickel and Inconel. Literature available.



DISSIMILAR METALS WELDING WIRE

A new item introduced at the 1958 Welding Show, Inco-Weld "A" Wire is a single product for inert gas welding of most combinations of dissimilar alloys. Technical Service and complete literature on request.

These "Plus Items" and many more are available in addition to a wide selection of corrosion-resistant sheet, rod and tube.

All told, there are more than 20,000 items distributed and serviced by Whitehead. All are available, off-the-shelf, from the nine Whitehead Metal "Supermarkets." All are the products of such leading producers as Alcoa, Anaconda, Inco & Crucible Steel to name just a few.

When you call Whitehead you get fast service, and frank, unbiased help in selection. Technical service when you need it. Add it up and you'll find it pays to

Call WHITEHEAD METAL PRODUCTS COMPANY, INC. First!

303 West 10th Street • N. Y. 14, N. Y.

Other Offices and Warehouses:
PHILADELPHIA • BUFFALO
HARRISON, N. J. • CAMBRIDGE, MASS. • SYRACUSE • BALTIMORE
ROCHESTER • WINDSOR, CONN.

For more information, turn to Reader Service card, circle No. 505

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, H.R.	5.10	7.52	—
Sheet, C.R.	6.27	9.27	—
Strip, H.R.	5.10	7.59	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.67	7.92	6.72
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.48-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.36	.48
403	.28	.34	.35	.40
420, 440	.34	.41	.45	.52
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.38	.44	.46	.56
446	.39	.44	.48	.70
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.70	.81	.85	.89
Precip Hard.				
17-7PH	.66	.73	.85	.90
PH 15-7 Mo	.86	.93	1.11	1.16

[a]Ingot price approx 60% of billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.07
316	1.26

[a]Price for —100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 188)

BOMBS AWAY...

with the help of heat-treated TITANIUM ALLOY

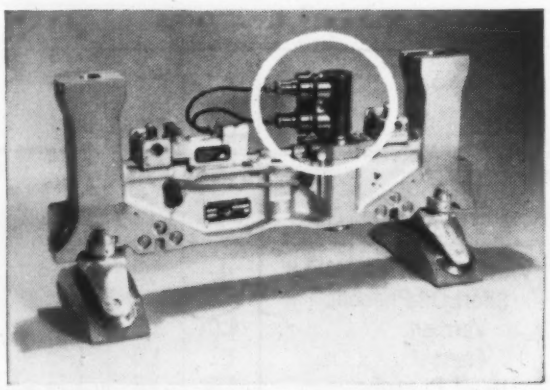
On high speed military planes, such as the Douglas A3D-2 Skywarrior and other jet aircraft, the bomb ejector rack is a complicated and critical mechanism. Any failure might endanger both airplane and pilot.

Three basic parts make up the ejector . . . cylinder, piston and breech. The latter presented the greatest design problem, due to its multitude of functions and irregular shape. Similar breeches made from stainless steel frequently heat-checked and failed, during test firing or hydrostatic testing.

Experience and design calculations suggested that 6Al-4V titanium alloy, produced by Mallory-Sharon, was the metal most likely to meet the exacting requirements.

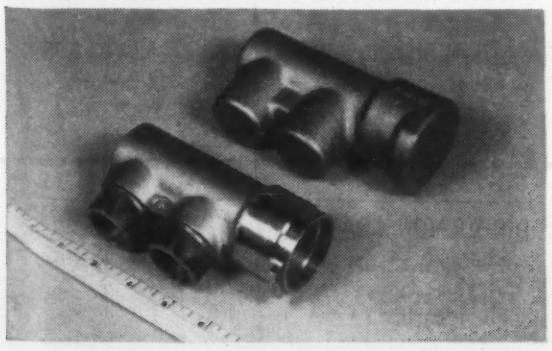
Actual firing tests confirmed the advantages of titanium for this application. The titanium alloy breech withstood 300 firings before any evidence of heat checking appeared. No failures occurred in firing . . . and the breech withstood hydrostatic pressure of 27,000 psi without failure.

Here's one more example of titanium's outstanding performance in meeting critical design problems. May we help you explore its advantages for *your* product or application? Write for "Titanium Fact File".



Above: Bomb ejector rack, showing forged titanium alloy breech (circled).

Below: Titanium alloy ejector breech, before and after machining.



WHY TITANIUM WAS CHOSEN

1. High strength-to-weight ratio at elevated temperatures for short times.
2. Superior corrosion and erosion resistance.
3. Excellent forgeability.
4. Good machineability in the heat-treated condition.
5. Low susceptibility to hydrogen embrittlement.
6. Good thermal stability.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

For more information, turn to Reader Service card, circle No. 421

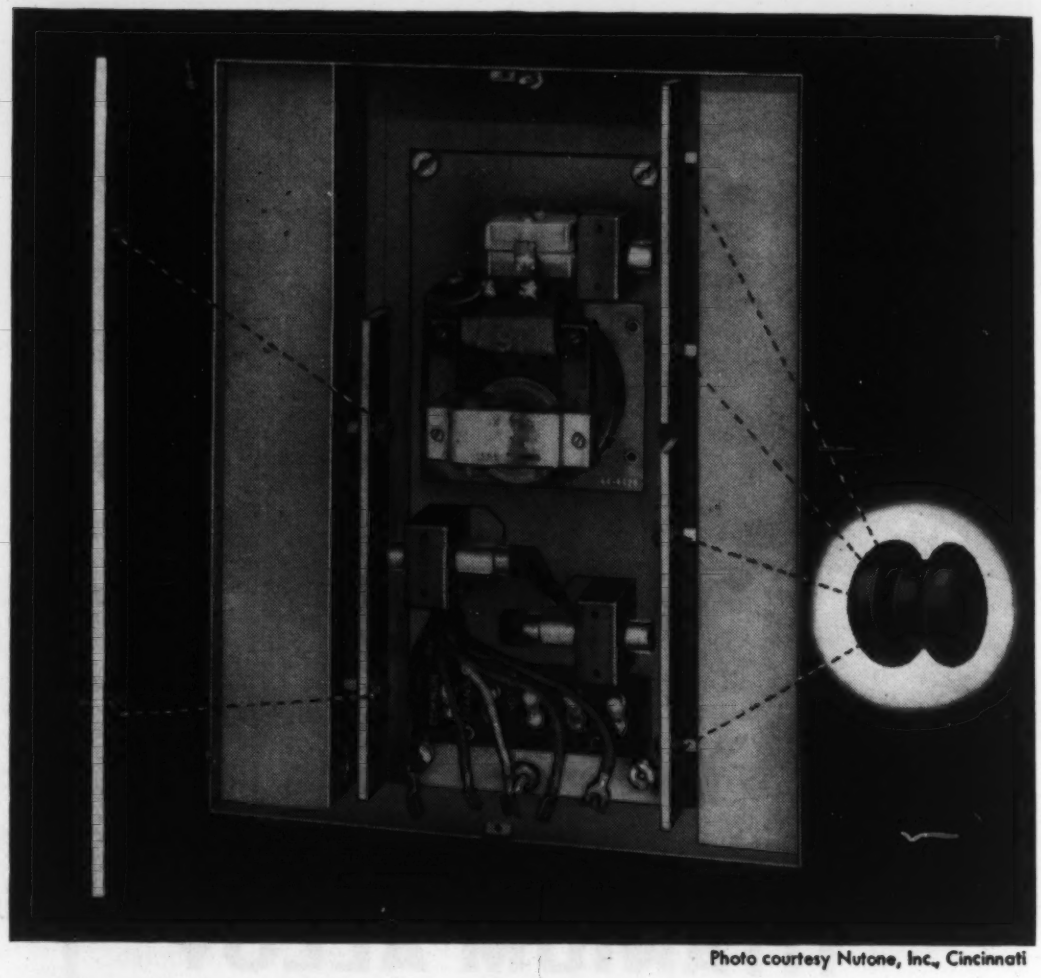


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**

CR *engineered by* **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 475

PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	38	42	47
304L	41	45	50
316L	49	55	60
321	40	45	49
347	42	48	53
430	30	33	37
Inconel	60	70	81
Nickel	52	62	73
Monel	54	64	74

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

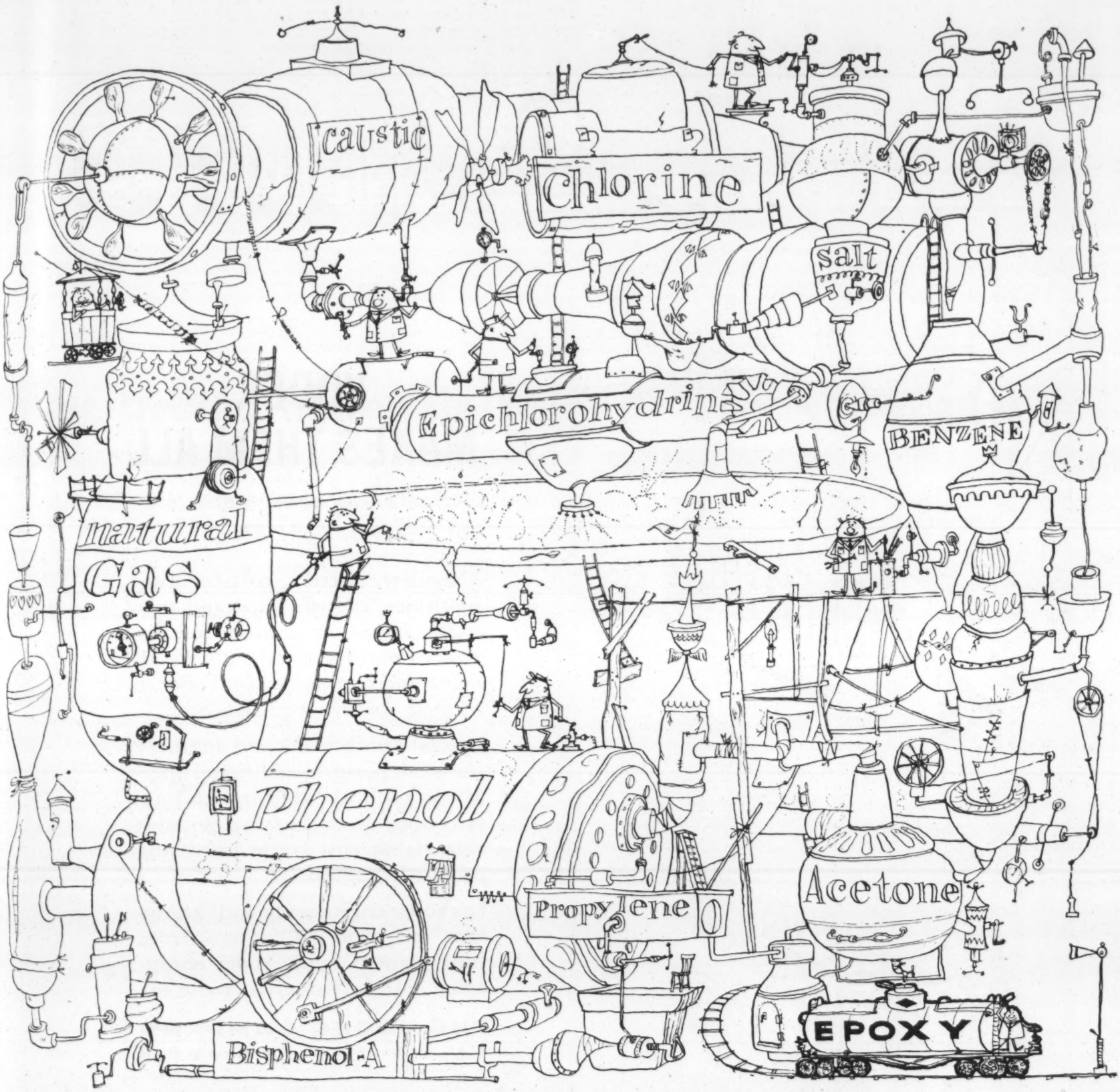
Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75- 9.40

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.



Dow's basic position in epoxy production assures purity, narrower "spec" range

New Dow Epoxy Resins provide outstanding purity because no other company makes so many (more than 93%) of the raw materials that go into them. And the one sure way to control purity of epoxy resins is to make the raw materials in your own plant, under your own supervision.

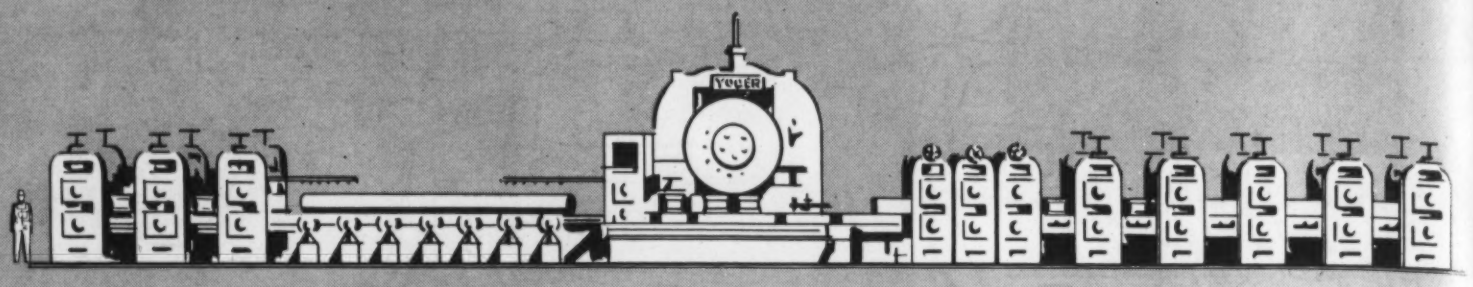
Purity is only one benefit enjoyed by users of Dow epoxies. Others are: better quality control, narrower range of specifications, an assured source of supply, and versatility of raw materials. The exclusive control of ingredients has resulted in new and improved epoxies such as D.E.R. 332 (new water-clear liquid resin) and Dow's new line of water-white solid epoxy resins.

With years of experience in producing epoxy raw materials, Dow can assure you Dow Epoxy Resins will best meet your highest specification standards. For information or copies of this cartoon contact your Dow sales office. Or write: THE DOW CHEMICAL COMPANY, Midland, Michigan, Coatings Sales Department 2260L.

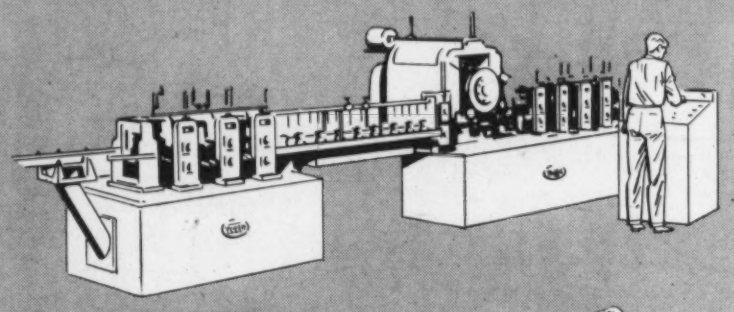
EPOXY T.M.

YOU CAN DEPEND ON DOW®

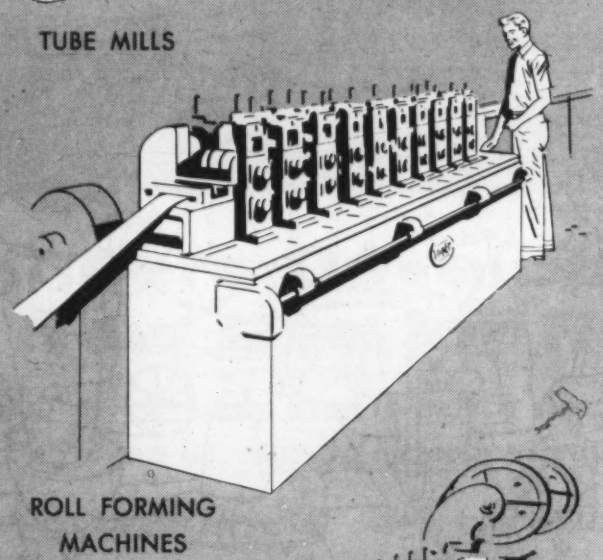
For more information, turn to Reader Service card, circle No. 454



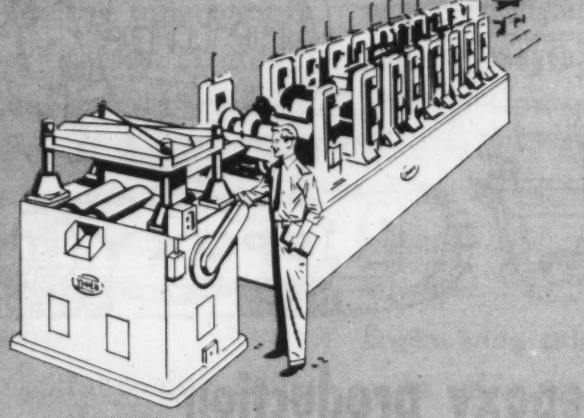
PIPE MILLS



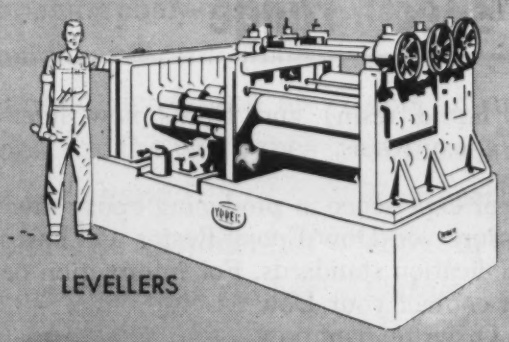
TUBE MILLS



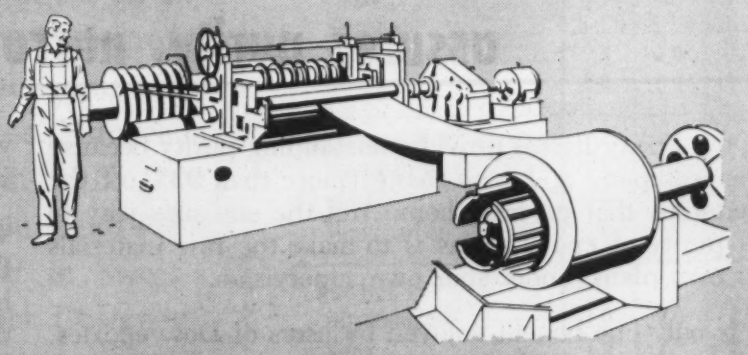
ROLL FORMING MACHINES



CUT-OFFS



LEVELLERS



RECOILERS SLITTERS UNCOILERS

YODER MAKES THEM ALL

...Complete equipment lines for heavy or light production!

Uncoilers, slitters, roll-forming machines, cut-offs, pipe and tube mills, special machinery for ferrous or non-ferrous metals are all made and engineered by Yoder to fit your specific requirements.

Special attachments and auxiliary units can perform additional operations such as welding, coiling, punching or embossing without extra labor cost while increasing production speed.

Let Yoder engineering and "know-how" help you get the most from your plant . . . with Yoder equipment. For full details, write to:

THE YODER COMPANY
5546 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES

For more information, turn to Reader Service card, circle No. 450

First Design Materials Show Set for Oct 8-10

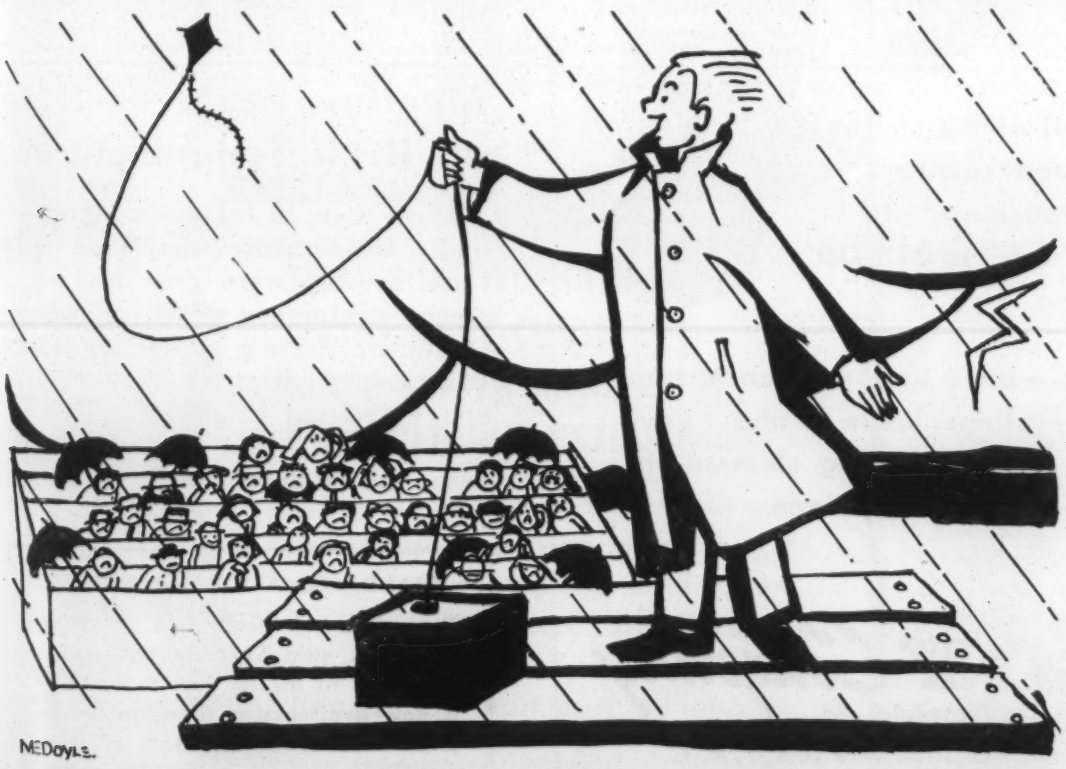
"Universal Design" is the theme around which Industrial Designers Institute will hold its first Annual Design Materials Show and Symposium. According to the Institute, the Show is devoted exclusively to those industrial designers, engineers, product planners, research directors, etc., who are responsible for the selection of materials in product design and development.

The Design Materials Show, to be held Oct 8-10 at the Sheraton-East Hotel, New York, will run concurrently with the annual national conference of the Industrial Designers Institute and will be immediately followed by the 5th annual symposium of the New England Chapter. Some of the technical sessions planned include: panel discussions on general design problems connected with the Brussels Fair; a progress report on student design, including examples of work; and a panel discussion called "Universal Design."

Exhibits at the show are designed to give industrial designers the opportunity to examine a wide range of the latest available materials, applications and techniques. Thus far, most of the exhibiting space has been reserved by producers of such things as metals, plastics, glass, wood, composition materials, textiles, and parts. Some of the participating companies include: Union Carbide Chemicals Co., U.S. Plywood Corp., Poloron Products, Inc., American Biltrite Rubber Co., Keeler Brass Co., Columbus Coated Fabrics Corp., Hawley Products Co., Polymer Corp., Eagle Ottawa Leather Co., Croname, Inc., Park Nameplate Co., Inc. and American Bleached Shellac Mfrs. Assn. Visitors will also be welcome at the MATERIALS IN DESIGN ENGINEERING booth.

For further information, contact Leonard S. Rogers, Orkin Exposition Management, 19 W. 44th St., New York 36.

THE HARD SELL



"Now, gentlemen, you've seen *how the material performs in the laboratory."*

Rubber Hardness Test Now Standardized

An international standard covering hardness testing of vulcanized and synthetic rubber has been approved by the 26 member nations of the International Organization for Standardization (ISO).

The hardness test, covered by Recommendation R48, involves measuring the penetration of a rigid ball into the rubber test piece under specified conditions. The measured penetration is then converted into International Rubber Hardness Degrees. The test corresponds to ASTM D1415-56T.

Copies of ISO Recommendation R48 can be obtained for 80¢ each from American Standards Assn., 70 E. 45th St., New York 17.

1958 Metal Show To Be Held in Cleveland

The 40th National Metal Exposition and Congress, sponsored by the American Society for Metals, will be held Oct 27-31 at the Cleveland and Statler-Hilton Hotels, Cleveland. According to Chester L. Wells, assistant director, about 500 individual exhibits and an attendance approaching or surpassing last year's 51,000 are expected this year.

This year's Congress will have a

DURASPUN SCREW CONVEYOR

Durable

. . . because it's properly alloyed

Strong

. . . because it's centrifugally cast

Centrifugal Castings can be more than conventional piping. Almost any roughly cylindrical shape can be cast centrifugally provided a straight hole through the center is allowable. In the casting machine the molten metal is thrown outward, making it impractical to cast solid.

This Duraspun Screw Conveyor is typical of the unusual castings produced in our centrifugal casting department. On straight piping, our machines are capable of turning out pipes ranging in 2½" to 31" OD and, according to diameter, up to 15' long.

If you are interested in superior castings — more uniform, denser and pocket-free castings — order centrifugal castings. Write us about your requirements and we'll recommend the proper alloying elements to meet your corrosive, high temperature, abrasive conditions.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 513

News OF INDUSTRY

broader scope than ever, according to Ray T. Bayless, assistant secretary of ASM. In addition to presentation of 50 technical papers by ASM's Transactions Committee, the Metals Engineering Program Committee, directed by Ted DuMond, will launch a new series of panel discussions. In addition, these other technical societies will participate: Society for Nondestructive Testing; Institute of Metals, Iron and Steel, and Extractive Metallurgy Divs. of the American Institute of Mining, Metallurgical and Petroleum Engineers; Industrial Heating Equipment Assn.; Metals Div., Special Libraries Assn.; Metal Powder Industries Federation; Metal Powder Committee of the American Society for Testing Materials; and the Metal Treating Institute.

The theme of the show will be "spending to save." According to Mr. Wells, "... management is faced with the necessity of improving techniques and modernizing equipment in order to effect production economies and to achieve lower competitive costs. This cost-cutting equipment and technical improvement are what virtually all 40th Metal Show exhibits will point up."

For further details concerning registration, technical program and complete list of exhibitors, see the October issue of M/DE.

Meeting Features Data on High Temperatures

More than 20 technical papers on high temperature materials and their sources were presented at a recent conference of the Southern California Section of the American Institute of Mining, Metallurgical and Petroleum Engineers.

The event, held in conjunction with the Molybdenum Fabrication

STANDARDS ARTICLES REPRINTED

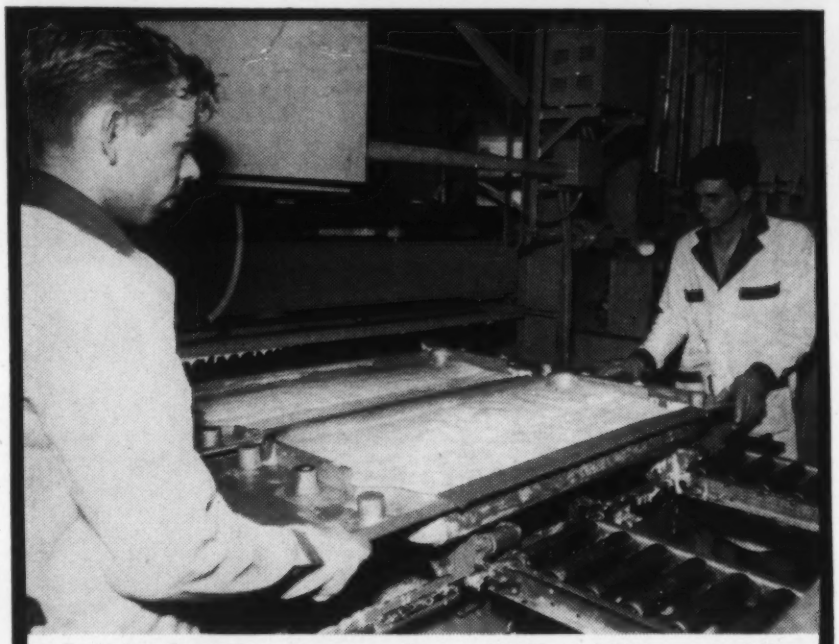
The six-part "Guide to Materials Standards and Specifications" which appeared in M/DE, Mar to Aug '58, is now available as an attractive 24-page reprint, as a result of many requests. Cost: 75¢ each in quantities up to 10; 60¢ each for 10 or more. Order from Reader Service Dept.

engineered ceramics?

IF YOU ARE LOOKING for a supply source capable of providing high-performance materials that give you resistance to high temperatures and low thermal expansion; excellent mechanical strength and wear resistance; superior dielectric strength and both high and low frequencies—

A GOOD SOLUTION to your problem is to check with Frenchtown. As one of America's leaders in engineered ceramics for over 40 years, we are in a position to serve you in three ways: (1) providing research facilities for product improvement through *engineered* ceramics, (2) assisting in design and development work, (3) producing required parts and components in any quantity, to your most exacting specifications. Want to know more? Write for literature.

frenchtown PORCELAIN COMPANY
Frenchtown, New Jersey

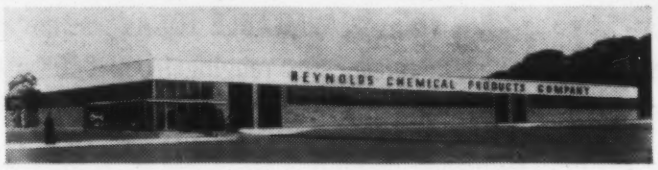


Foaming begins in a seat cushion mold for a 1959 automobile

REYNOLDS IS MOVING WITH MOLDED POLYETHER URETHANE FOAM!

Design engineers by the dozen are finding that *molded* urethane foam cushions better and cheaper than rubber. And they're finding, too, that only Reynolds has fully mastered molding techniques...that only Reynolds offers optional *coring*.

Fact is, Reynolds is moving ahead so rapidly in the urethane foam field that we're moving right out of our present plant!



After September 15, 1958, REYNOFOAM* operations will be quartered in our big, modern new plant in Whitmore Lake, Michigan. This means even better service and quality control for our customers.

Isn't this a fine time to specify REYNOFOAM in commercial quantities? You can bet that REYNOFOAM will fully equal specifications for any cushioning application. *Write today for full information.*

Reynolds Can Mold It — If Anyone Can!

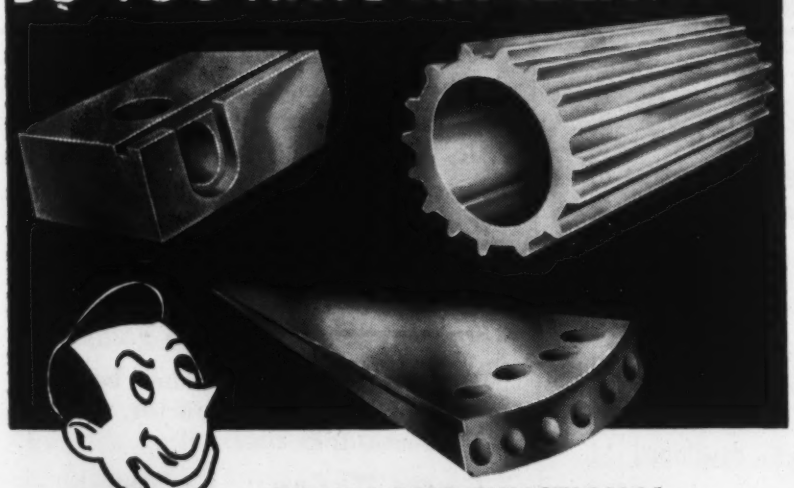
REYNOLDS CHEMICAL PRODUCTS COMPANY

1200 North Main Street Ann Arbor, Michigan

DIVISION OF STUBNITZ-GREENE CORP.

* Reg. Trademark

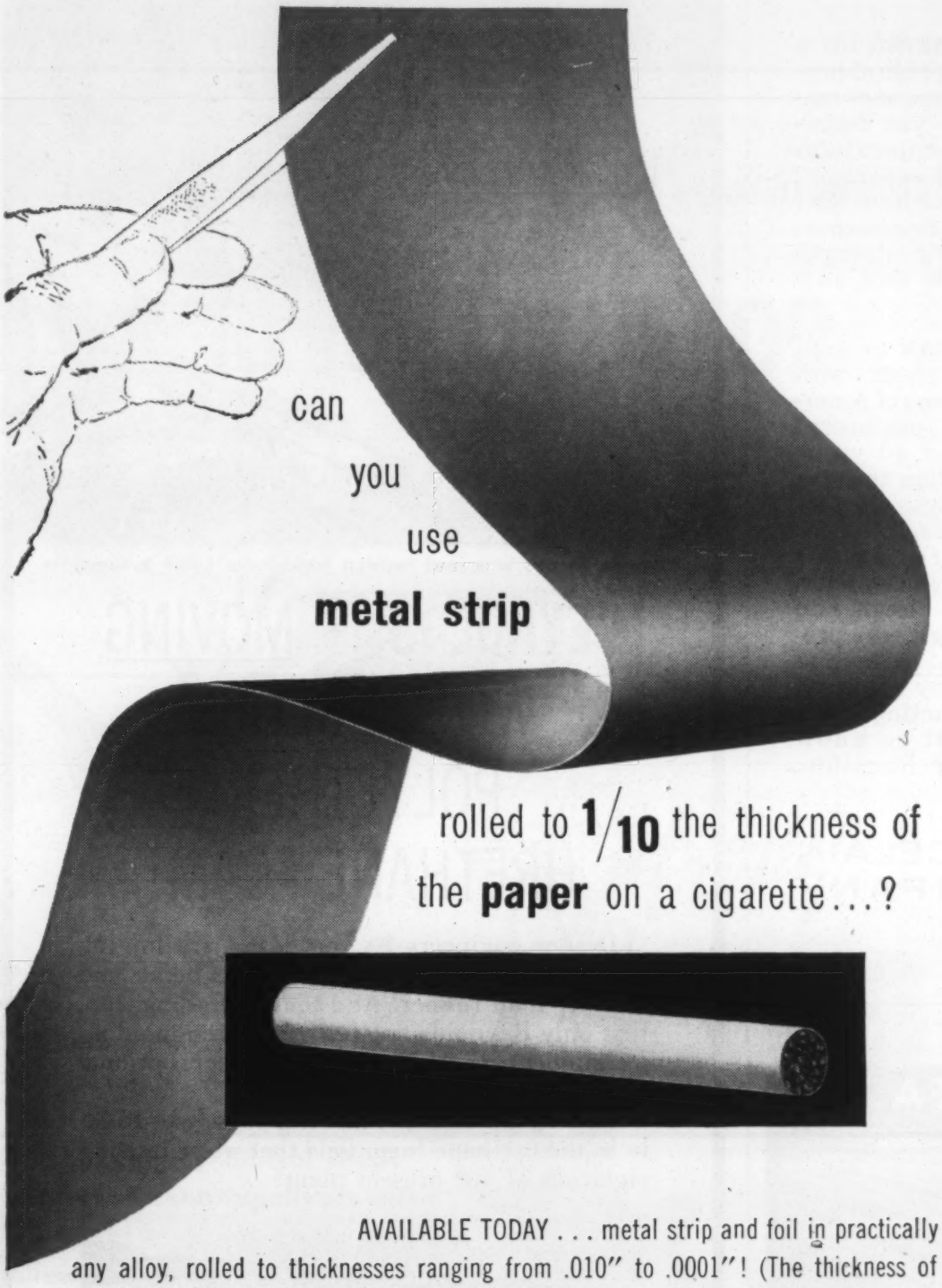
DO YOU HAVE AN IDEA...



THAT SOME FUNCTIONAL METAL PART COULD BE MADE BETTER OR CHEAPER BY ALUMINUM EXTRUDING?

Bring your idea to specialists in adapting aluminum extrusions to new functional parts applications. G. E. I.'s engineers are ready to consult with you, without obligation, on one part or a million.

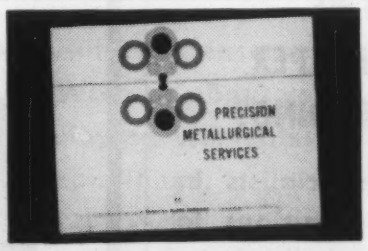
GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO



AVAILABLE TODAY . . . metal strip and foil in practically any alloy, rolled to thicknesses ranging from .010" to .0001"! (The thickness of cigarette paper is .00125".) The Precision Metals Division of Hamilton Watch Company is today producing these materials in quantities for either developmental work or production, meeting exact mechanical, magnetic and physical specifications.

Precision Metals Division, established by Hamilton to provide special metallurgical services in the manufacture of fine American watches, is a modern, completely integrated plant geared to precision production. Special alloys, developed to customer specifications, are also available in whatever form required.

With emphasis today on miniaturization and subminiaturization, designers and engineers are solving important problems with metal strip and foil from Precision Metals Division. To find out more about this unique service, write today for a copy of this new facilities book. Write on your letterhead to Dept. DE-9



Hamilton Watch Company

Precision Metals Division / Lancaster, Pennsylvania

Creator of the world's first electric watch

For more information, turn to Reader Service card, circle No. 471

News OF INDUSTRY

Conference of the Southern California Chapter of the American Society for Metals, covered: mechanical properties of refractory oxides; high temperature strength and creep in graphite; strength and low temperature creep; refractory metals, tungsten, molybdenum, columbium and nickel; behavior of ceramics at high temperatures; high temperature structural properties; high temperature oxidation; trends in refractory metals; mechanical properties of ceramics; physical properties of nonmetallics; etc.

Electrochemical Society to Meet End of Month

The 114th meeting of the Electrochemical Society will be held Sept 28-Oct 2 at the Chateau Laurier, Ottawa, Canada. Technical sessions scheduled for the meeting will be conducted by seven of the Society's divisions: Battery, Corrosion, Electro-deposition, Electronics (semiconductors), Electro-Organic, Electrothermics and Metallurgy, and Theoretical Electrochemistry.

For further information, contact R. A. Campbell, Electrochemical Society, 552 Booth St., Ottawa 1, Ont.

Engineers

Dr. Clarence Bremer has been appointed technical director, Oakite Products, Inc.

George H. Gustat, Eastman Kodak Co., has been elected president of the American Institute of Industrial Engineers.

Dr. Peter L. Shanta has been appointed technical director, Taylor Fibre Co.

Jacques J. Weinstock is now senior scientist, Radiation Applications Inc.

John A. Dersch has been named director of engineering, Read Standard Div., Capitol Products Corp.

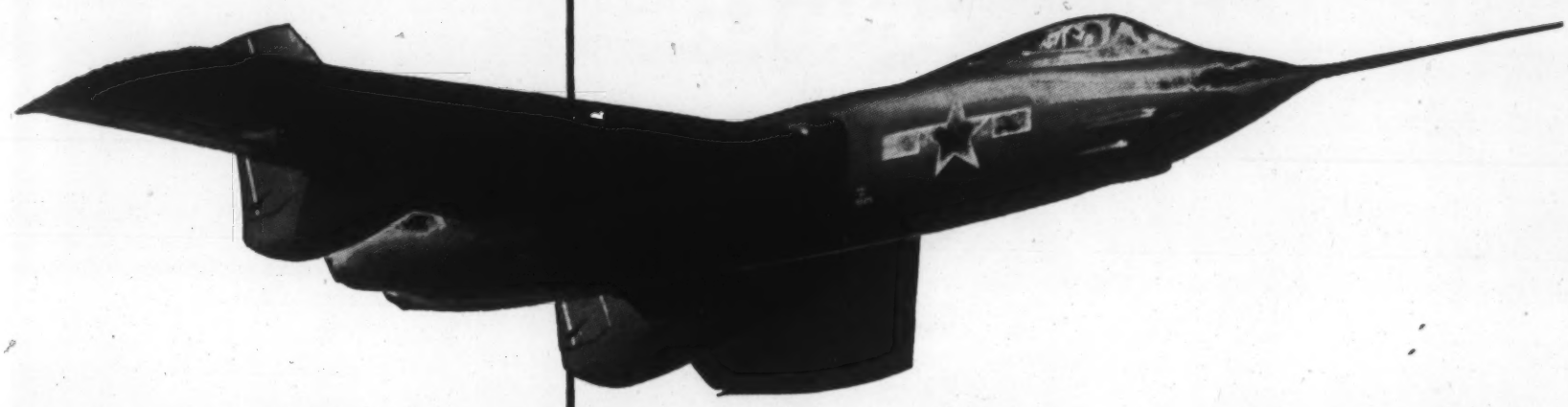
Herbert S. Kalish has been appointed section chief of materials, Metallurgical Laboratories, Olin Mathieson Chemical Corp.

Dr. Kuang Lu Cheng has been named associate director of research, and **Dr. Adolph Edward Palty** super-

For your selection

ALTEMP

HIGH TEMPERATURE SUPER ALLOY STEELS



ALTEMP A-286 . . . an austenitic iron-nickel-chromium alloy made heat-treatable by the addition of titanium. Designed to maintain high strength and corrosion-resistance up to the 1350 F range, and to afford satisfactory scale resistance up to 1800 F.

A-286 was developed in the A-L Research Laboratory in Watervliet, N.Y., in the 1949-51 period. Among the high-strength, heat-resisting alloys, it has exceptionally low strategic alloy content, improved hot-working and machining qualities, and good center ductility in large sections. Currently used in jet engines and superchargers for such applications as turbine wheels and blades, frames, casings, afterburner parts, bolting, etc.

This alloy is readily produced in large quantities without the need of special steel-making equipment. It is available in the form of billets, bars, forgings, sheet, strip, tubing and hot-extruded shapes.

ALTEMP S-816 . . . a chromium-nickel-cobalt base alloy, strengthened by additions of molybdenum and tungsten, and with a columbium-carbon ratio of ten to one to insure its structural stability. Designed for high strength and corrosion-resistance service in the 1200-1500 F range, and at higher temperatures under lower stress conditions. Developed in the A-L Research Laboratory at Watervliet, N.Y. in the years of 1940-43, and engine-tested and proved for periods of over 30,000 hours.

S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

ALTEMP S-590 was designed for service in the range of 1100-1400 F temperatures where high strength and corrosion resistance are required, and where cost is also a factor. Unlike S-816, which is practically a non-ferrous alloy, S-590 has a chromium-nickel-cobalt-iron base. However, it employs the same molybdenum and tungsten additives, and the same columbium-carbon ratio.

S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

OTHER GRADES . . . among the many other Super Alloys made by Allegheny Ludlum are V-36, M-252, 19-9 DL, 19-9 DX and Waspaloy.

Do you have a high temperature problem? The services and experience of our Research Laboratories and Technical Staff are completely at your command. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 8310 B

WRITE FOR INFORMATION

Certified laboratory data on the properties of Allegheny Ludlum high temperature Super Alloy Steels are yours on request.

ADDRESS DEPT. MM-9-A

PIONEERING on the Horizons of Steel

Allegheny Ludlum

Stocks of AL Stainless Steels carried by all Ryerson warehouses

AL® LEADING PRODUCER HIGH-ALLOY STEELS

For more information, turn to Reader Service card, circle No. 484

I-S solves tough production problem

—to meet critical

ELECTRO SNAP

SPRING "SPECS"

OVERLAP ON CONTACT POINTS WAS CONSIDERED IMPOSSIBLE TO MASS-PRODUCE. I-S ENGINEERS PRODUCED THE PART WITH PRECISION TO SPARE

Hermetically Sealed Limit Switch employs I-S Beryllium Copper Flipper Blades

- **FOR SUPER PRECISION ACCURACY**
- **COMPLETE FREEDOM FROM FATIGUE**

The Electro-Snap component illustrated is hermetically sealed, ruggedly constructed to provide an environment-free, super-durable limit switch. The I-S flipper blades of beryllium copper offer excellent electrical characteristics, super precision accuracy and freedom from fatigue. If you have a spring problem, I-S engineers will be happy to explain the unique advantages of Beryllium Copper and make specific recommendations.

Write or call today for the I-S catalog on Beryllium Copper compression springs, flat springs, strip springs, contact strips, contact rings and screw machine parts.

INSTRUMENT SPECIALTIES CO · INC

224 Bergen Blvd., Little Falls, New Jersey

Telephone: Clifford 6-3500

"MICRO-...PROCESSED" I-S BERYLLIUM COPPER SPRINGS

For more information, turn to Reader Service card, circle No. 496

News OF INDUSTRY

visor, alloy development and evaluation, Utica Metals Div., Kelsey-Hayes Co.

Grant A. Morrison is now manager, product design and application engineering, Metallurgical Products Dept., General Electric Co., Detroit.

Dr. Oscar O. Miller, International Nickel Co., Inc., has been elected president of the Technical Societies Council of New Jersey, Inc.

Darle W. Dudley, General Electric Co., has received the Edward P. Connell award, given annually by the American Gear Manufacturers' Assn.

Dr. Phillip W. Lett has been named chief engineer, and **Walter C. Beyer** assistant chief engineer, Defense Engineering, Chrysler Corp.

Kenneth W. Donle has been named chief engineer, Tube Reducing Corp.

Carl R. Canfield has been appointed to the newly created position of chief engineer, Product Development Dept., Engineering Div., Crane Co.

Arthur M. Moody has been named chief product development engineer and Arne Frank, senior development engineer, reciprocating compressors, Trane Co.

Frank L. Bracy has been promoted to technical service engineer, Plax Corp.

Wayne A. Deringer, A. O. Smith Corp., is now president of the National Institute of Ceramic Engineers, an affiliate of the American Ceramics Society.

Douglas McHenry, Portland Cement Assn., has been elected president of the American Concrete Institute for 1958.

J. E. Massey has been appointed chief engineer, Delta Tank Mfg. Co.

Dr. William H. Duerig has been named vice president in charge of research and engineering, Midwestern Instruments, Inc.

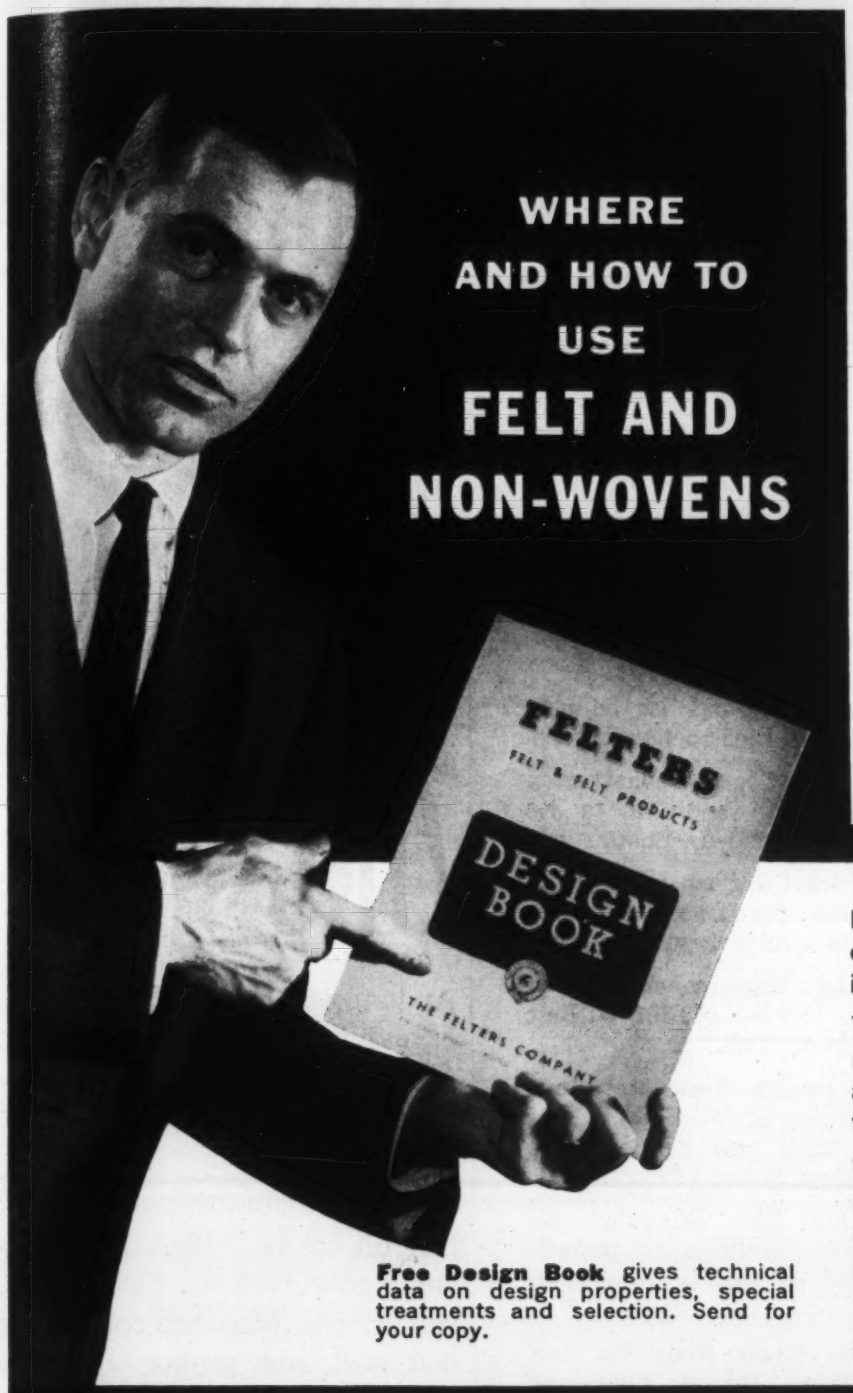
Dr. J. H. Hollomon, General Electric Research Laboratory, has been awarded the Rosenhain Medal for 1958 by the Institute of Metals, London, England.

Richard S. Morse, National Research Corp., has been appointed chairman, Army Scientific Advisory Panel.

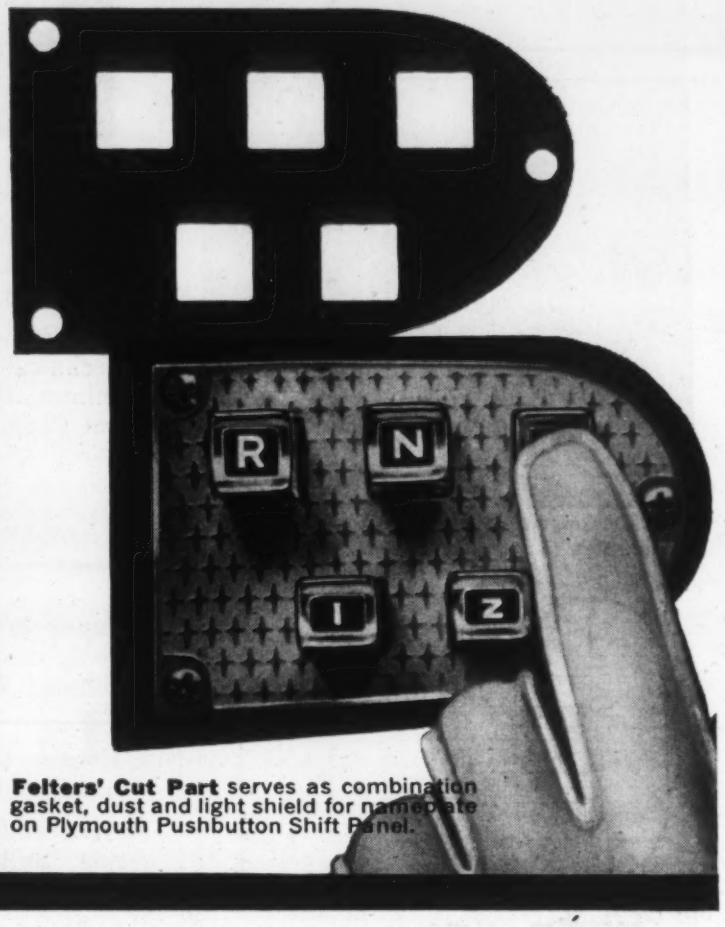
Donald E. Fandrey is now research engineer, International Railroads' Weighing Corp.

W. J. Brown has been named staff product application engineer, Mar-

PHOTO REPORT:



Free Design Book gives technical data on design properties, special treatments and selection. Send for your copy.



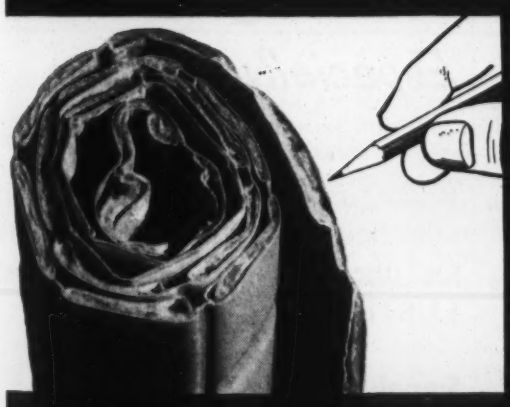
Felters' Cut Part serves as combination gasket, dust and light shield for nameplate on Plymouth Pushbutton Shift Panel.

Felters' range of non-woven and felted-type fabrics offer wide combinations of characteristics not found in any other material.

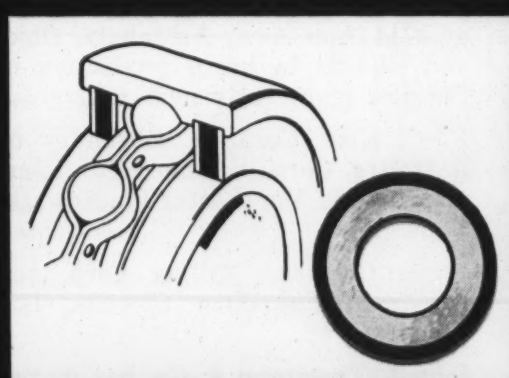
These fabrics can be made tough, stiff or dense, as required. Also water repellent, flameproof, and moth and mildewproof. Ideal for absorptive wicking and filtering applications.

Synthetics, too, are giving non-wovens new uses and properties, particularly in smoothness, abrasion resistance, and long life.

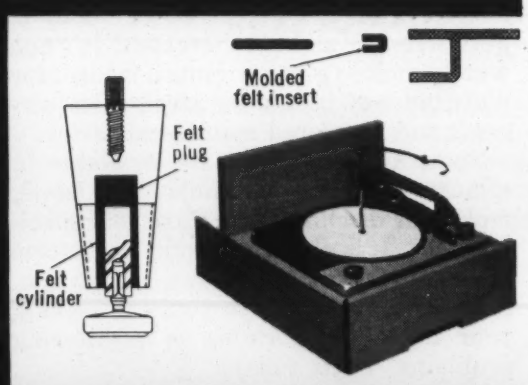
Call on Felters for all types of felt and non-woven fabrics, including special treatments, impregnations and fiber mixes.



AllFab is a special Felters' non-woven fabric. Has thermoplastic resin binder and can be electronically stitched, sealed and embossed. Available in wide range of fiber combinations in thicknesses from 1/16" to 1" and more. Used for backing, filling, and plumping. Available with synthetic mixes such as Orlon®, with varying degrees of "loft."



Felt Pads (Prelubricated) prolong bearing life! Special tests show that oil saturated felt rings provide a built-in "slow bleeding" action to lubricate bearings. Functions over wide temperature range at speeds up to 10,000 rpm, without excessive starting friction at low temperature or poor stability at high temperature.



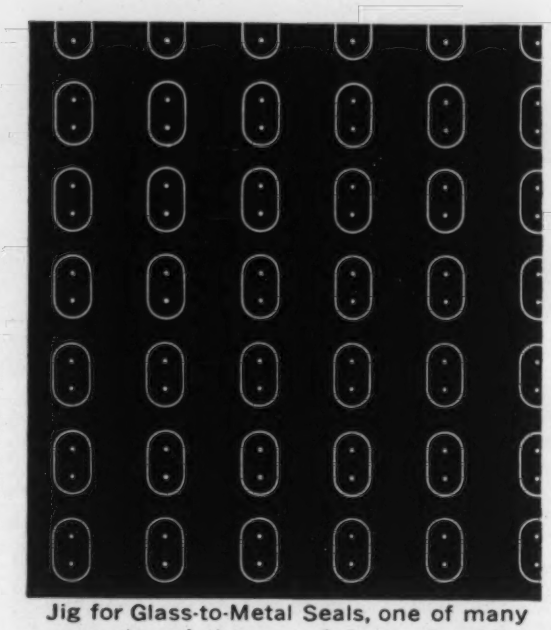
Hi-Fi Sets Use Felt in a number of places. Record changer drawers slide on aluminum channel with molded in felt insert. This provides light compression fit, eliminates resonant metal-to-metal contact, absorbs vibration and insures smooth action. Special felt lined piston legs eliminate floor vibration which affects performance.

the **FELTERS** company

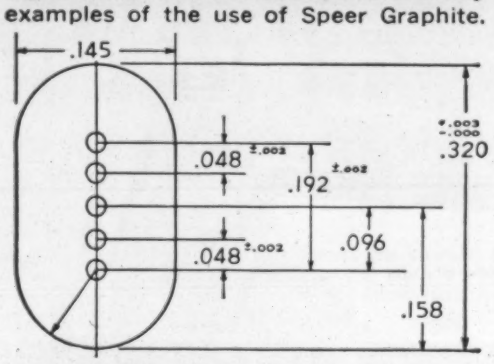
220 SOUTH ST., BOSTON 11, MASS.

Pioneer producers of Felt and Felt Products

For more information, turn to Reader Service card, circle No. 412



Jig for Glass-to-Metal Seals, one of many examples of the use of Speer Graphite.



NEED JIGS— FIXTURES FOR HIGH-TEMPERATURE JOBS? TRY SPEER GRAPHITE!

Transistor Jigs, Fusing Positioners, Honeycomb Jigs, Furnace Fixtures, Brazing Jigs, Glass-to-Metal Seals, etc.

In long-term high-heat applications, graphite is first choice for jigs and fixtures. Graphite doesn't warp . . . won't split or break down under severe thermal shock . . . is chemically inert . . . actually gets *stronger* as heat increases! It's not wet by molten glass or metal, is ideal for multitudes of jobs in the electronics, aircraft and powdered metals industries.

Speer Graphite Jigs are available in almost any size and shape you name, molded or machined *exactly* to your specifications. It is also supplied in block form if you prefer to do your own fabrication. Add our experience to yours in solving your high-heat forming or positioning problems. Write today!

SPEER Carbon Co. St. Marys, Pa.

I'd like to know more about graphite jigs or fixtures for this application:

_____

_____

NAME_____ TITLE____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE____

For more information, circle No. 387

News of Industry

keting Technical Service Div., Gulf Research & Development Co., a subsidiary of Gulf Oil Corp.

Harry B. Burrack has been appointed technical superintendent, Olin Aluminum Div., Olin Mathieson Chemical Corp.

Companies

Jones & Laughlin Steel Corp. has completed its new $17 million Continuous Weld Pipe Mills, Aliquippa, Pa.

Hooker Chemical Corp. is the new name of Hooker Electrochemical Co.

General Electric Co. will construct a new million-dollar addition to its Philadelphia Switchgear Laboratory.

L. Frank Markel & Sons has formed a **Flexlead Div.** for the manufacture of high temperature insulated wire.

Ladish Co. has begun operations in its new plant located at 1301 W. Belt Dr. N., Houston, Tex.

W. B. Ford Design Associates, Inc., is now the name of W. B. Ford Design Corp., with new headquarters at 200 Woodward Ave., Detroit.

Johns-Manville has expanded its manufacturing facilities to include production of a variety of Teflon products.

Molded Fiber Glass Body Co. has purchased from **Inland Container Foundation, Inc.** a 60,900-sq ft plant at 3714 Ann Ave., Ashtabula, Ohio, and expects to begin production in the new plant early next fall.

F. C. Kent Corp., a subsidiary of **Bart Mfg. Corp.,** has moved to a new plant at 130 Manchester Pl., Newark, N. J.

U. S. Chemical Milling Corp. has purchased **Foto-Etch Circuits,** Los Angeles.

John I. Thompson & Co. has moved its executive offices and engineering divisions to 1118 22nd St. NW, Washington 7, D. C.

Robertshaw-Fulton Controls Co.'s Fulton Sylphon Div. has opened a product development laboratory in Knoxville, Tenn.

Celanese Corp. of America has constructed a new polyvinyl acetate emulsion manufacturing unit at its Belvidere, N. J., plant.

Illinois Gear & Machine Co. has completed a new plant expansion

LUSTER-ON®

PIONEER IN

CHROMATES

NOW OFFERS DECORATIVE

COLOR

ON ECONOMICAL

ZINC

At long last you can now secure beautifully bright, gleaming colors from a simple LUSTER-ON chromate dip process for your zinc plated small parts.

These are not just spotty indentification colors. These are scintillating golds, yellows, blues, greens, violets, reds, brass and copper hues that will add glamor and sales appeal.

Especially Brilliant on Wire Goods

Be the first in your field to offer this sales booster. Write or wire today for the full story on low-cost LUSTER-ON COLOR.

Samples Gladly Processed Free

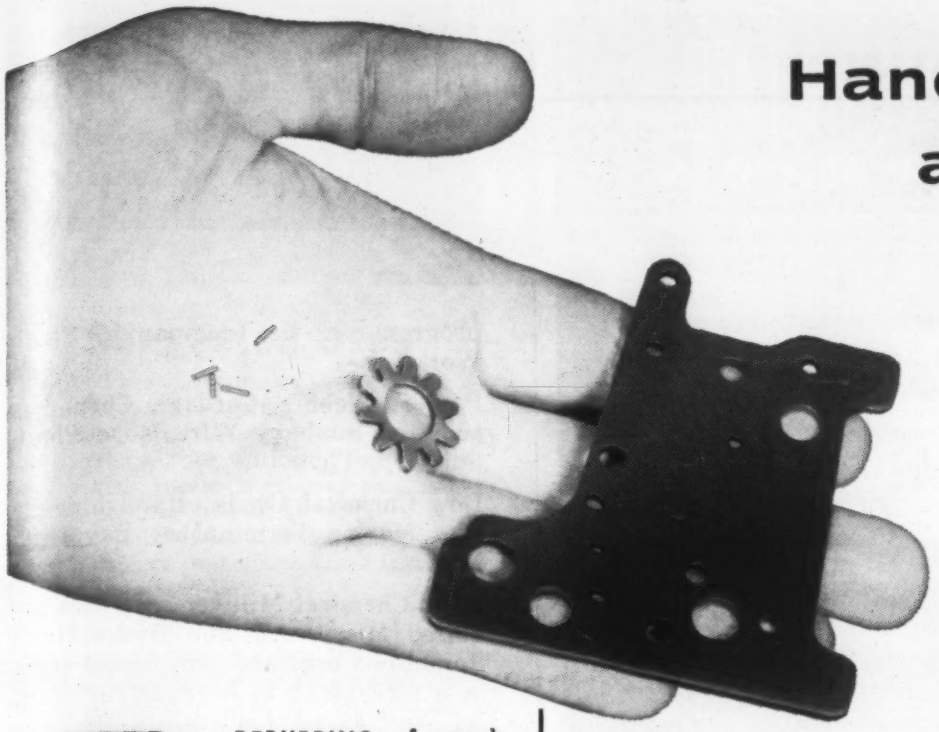
West Coast: Crown Chem. & Engr. Los Angeles & San Francisco

Canadian Licensee: Alloycraft Ltd., Montreal

THE *Chemical* CORPORATION

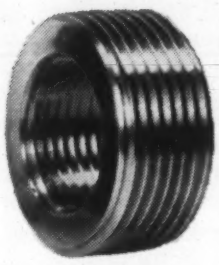
67 Waltham Ave., Springfield 9, Mass.

For more information, circle No. 434

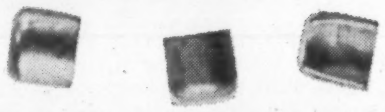


Hand Your Deburring and Finishing Problems to ALMCO...

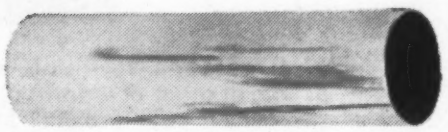
These companies did... and cut costs, improved quality, increased production.



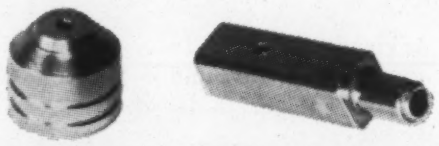
DEBURRING of spark plug bushings by hand formerly caused many rejects at Canadian Pratt and Whitney. Costs were $104.20 per M with rejects totalling 12½%. Two Almco barrel finishing machines cut costs 97%, practically eliminated rejects.



SMALL GREASE GUN COUPLER JAWS (½" x ⅜") couldn't be deburred manually at a midwest screw products firm. With an Almco barrel finishing machine, 40,000 coupler jaws can now be deburred in 10 hours. Jaws are smooth, uniform, ready for plating.



DEBURRING AND POLISHING by manual methods proved expensive for delicate instrument and fountain pen parts at J. Bishop & Co. Almco barrel finishing machine increased output from 200 to 6000 parts per hour, cut costs 98.8%. Annual savings: $6,917.50.



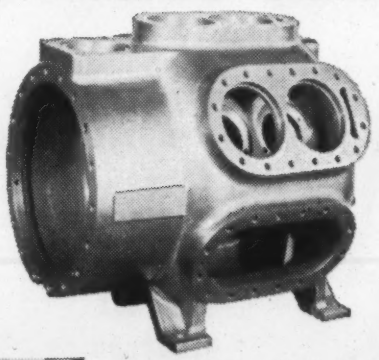
INCREASED PRODUCTION quotas demanded faster finishing at Alco Valve Co. Hand deburring and polishing finished only 200 stainless steel parts per hour. Almco machines are now barrel finishing over 1400 per hour, and to stricter finishing specs. Plant production needs are easily filled.

FILING burrs by hand formerly cost $55 per 100 needle plate forgings at Landis Machine Co. Now an Almco barrel finishing machine has cut finishing costs to 55 cents per 100 parts. Parts are uniform, rejects are eliminated. Savings come to 99%!

See Barrel Finishing In Action At Our Display, Booth 2101, ASTE Show, Philadelphia

Large Parts too are Almco Barrel Finished!

AT AN IOWA FOUNDRY, an Almco barrel finishing machine deburrs, polishes 48 large wash machine agitators per hour. Fixtures hold castings firmly within Almco barrel. Rough edges are completely removed; castings are highly polished; appearance is improved.



AT AIR CONDITIONING FIRM, compressor housings weighing over 100 lbs. are Almco barrel finished. Almco process breaks sharp edges of castings, cleans internal surfaces, and improves surface finishes. Two housings are cleaned in 20 minute cycle! Workmen are relieved for other plant tasks!

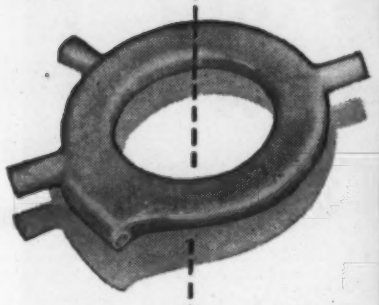
Send Your Parts to Almco's Modern Test Laboratory.

Sample parts processed without obligation. Simply write on letterhead, sending parts direct to Albert Lea, enclosing specifications required. Complete, free report includes recommendation. 52 PAGE HANDBOOK ON BARREL FINISHING SENT ON REQUEST.

ALMCO

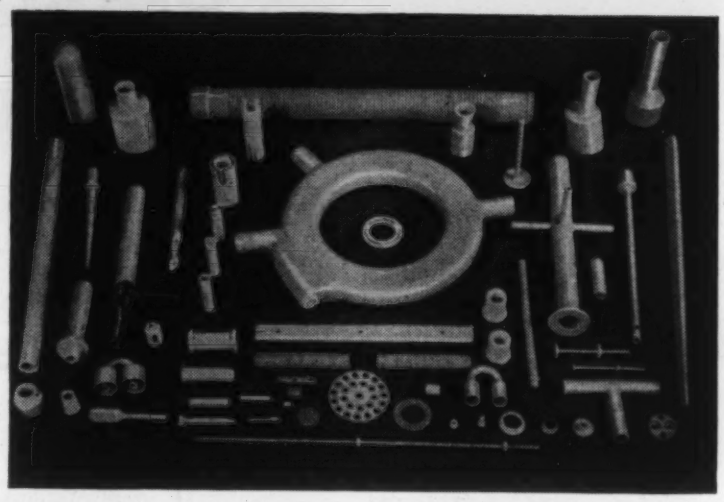
QUEEN PRODUCTS, INC.
39 Marshall Street • Albert Lea, Minnesota
Subsidiary of KING-SEELEY Corporation
Sales Engineering Offices in Chicago, Detroit, Los Angeles, Newark, New Haven, Philadelphia and London, England.
IN ENGLAND: *Almco Division of Great Britain, Ltd., Hitchins, Herts, England*

For more information, turn to Reader Service card, circle No. 406



McDANEL CERAMICS

may be your ANSWER

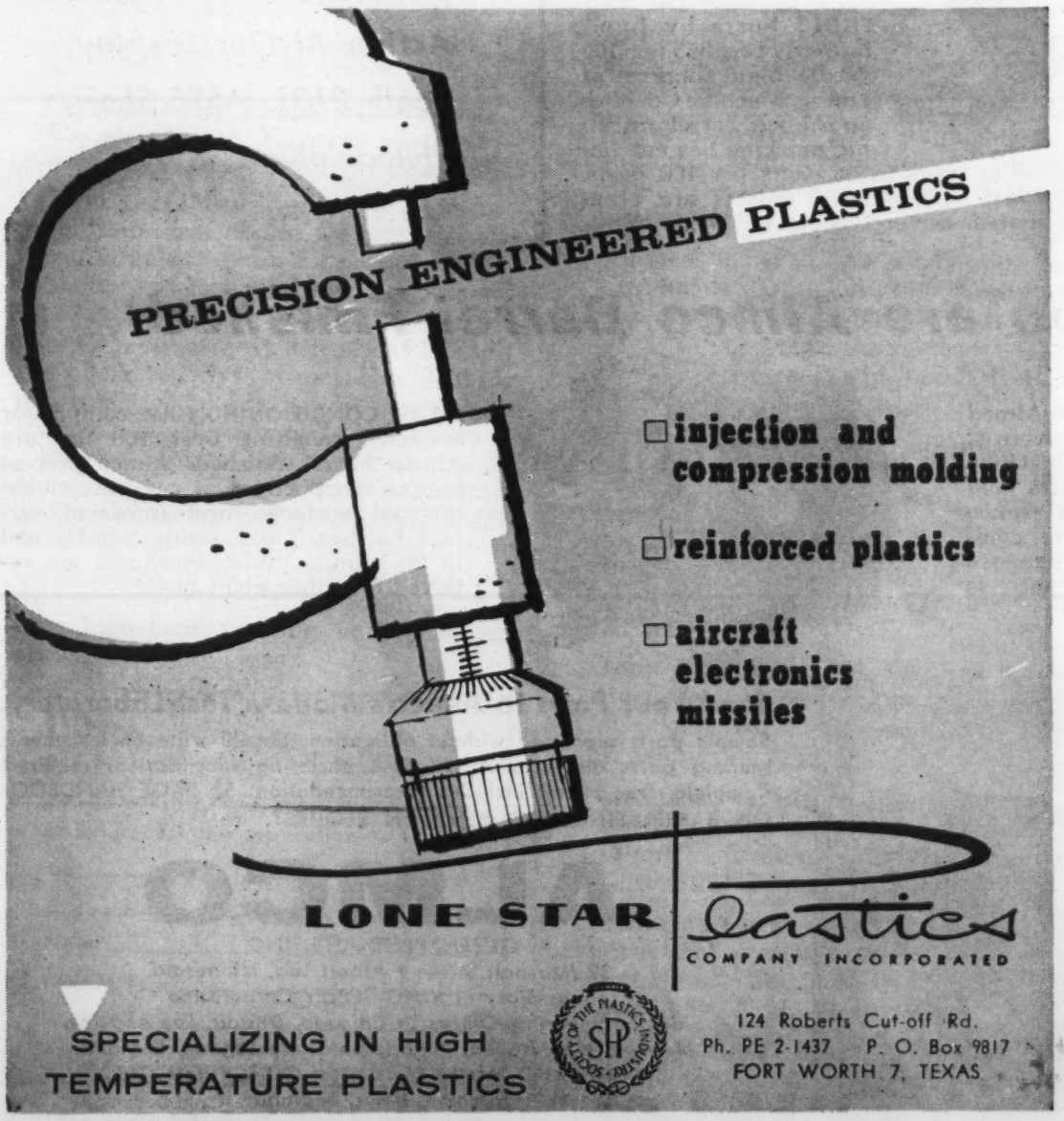


Heat, abrasion, corrosion, chemical action, or other deteriorating factors present on your project? McDanel specially-developed ceramics could be the answer. Scientists, physicists, research and development engineers are applying McDanel ceramics to a wide variety of difficult applications with good success. Our engineers develop special dies, designs, even new processes to suit your particular need. Try ceramics.

McDANEL Industrial CERAMICS

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS · PENNSYLVANIA

Let us study a sketch of your application. Your inquiry is special to us.



For more information, turn to Reader Service card, circle No. 382

News OF INDUSTRY

program at the company's South Works.

Paulsen-Webber Cordage Corp. has acquired **Sunbury Wire Rope Plant**, Sunbury, Pa.

Dow Chemical Co. is establishing its own Marine Terminal at Bay City, Mich.

U. S. Chemical Milling Corp. has acquired **Missile-Air** and **Hydro-Metal Spinning Corp.** and will house them in a new plant to be constructed at its West Coast facility.

John Wood Co.'s Haverly Equipment Div. has begun production in its Royersford, Pa., plant.

E. I. du Pont de Nemours & Co. has announced a long-range expansion program under which six new plants will be added to its present facilities.

Eaton Mfg. Co. has completed a new 21,500-sq ft general office building for its **Dynamatic Div.**, Kenosha, Wis.

Arvin Industries, Inc. has expanded its facilities to include the manufacture of plastic tools, dies, gages and prototypes.

Goodyear Tire & Rubber Co. has begun construction of a new $9 million film plant at Apple Grove, W. Va.

Austenal, Inc.'s Microcast Div. has moved to its new $4 million precision casting plant at La Porte, Ind.

American Cyanamid Co. has begun production at its recently completed multi-million dollar catalytic aniline plant.

Borg-Warner Corp.'s Pesco Products Div. has announced the acquisition of **Precision Engineering & Gear Co.**

Isochem Corp. has formed a new affiliate, **Isochem Resins Corp.**

Flexible Tubing Corp. has opened its new 16,300-sq ft plant at 305 Crescent Way, Anaheim, Calif.

National Starch Products Inc. has moved to new quarters at 750 Third Ave., New York 17.

Vertol Aircraft Corp. has acquired **Allied Research Associates, Inc.**, and **ARA Productions Inc.** as wholly owned subsidiaries.

Palmer-Bee Co. announces the formation of **Autocon Div.** with headquarters at 1929 Opdyke Rd., Pontiac, Mich.

HEF Inc. is the name of a new corporation formed jointly by **Hooker Electrochemical Co.** and **Foote Mineral Co.** The new firm will special-

Double-Face®

READY-TO-USE ADHESIVE FILM CUTS FASTENING TIME & COSTS

Suggested Uses

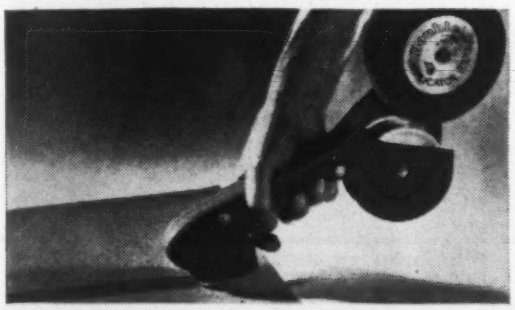
Double-Face is ideally suited to the temporary positioning of metal, glass or plastic parts in product assembly; roll starting and splicing, lap sealing, bonding of name tags and instruction plates, sealing of plastic film — wherever a quick, strong, pressure-sensitive bond will save materials, time and labor.

Application

Unrolling Double-Face exposes one tacky surface for application to a material. Removal of the release paper immediately, or at a later time, exposes the second side of the film for instant bonding.

Film widths of ½", ¾", 1¼" and 1¾" are also available with a dry edge release paper extending ⅛" on each side of the film to facilitate removal.

For high speed transfer of the film, including automatic removal of release paper, Angier has developed a portable hand applicator accommodating film widths from ½" to 1".



Economical to Use

Typical Double-Face costs range from 10¢ per sq. ft. in 54" rolls to 1/10¢ per sq. inch in average tape widths. The strength of even 1 sq. inch of Double-Face permits many bonds to be made with great savings over the use of conventional fastenings.

New uses found every day for Double-Face Pressure-Sensitive Transfer Film

Pressure-sensitizing polyurethane foam. One side of Double-Face Film has already been applied to foam. Picture shows release sheet being stripped from second side.

Film Form Offers Unusual Advantages

Because of its pliable, pure adhesive body, Double-Face Film conforms readily to irregular surfaces such as embossed materials. It also differs from similar products in its ability to wet into porous materials, such as foams and felt, for stronger bonding without undesirable penetration. The film can be die cut or slit with protective release paper in place. And laminates — with only the film between them — can be bonded to a closer tolerance.

To meet the need for a more convenient instant-bonding medium for a full variety of porous and non-porous materials, Angier Adhesives has developed Double-Face — a pure translucent pressure-sensitive adhesive film. The first product of its type, Double-Face is reinforced by a non-woven tissue, and supported for shipping, handling and storage by a release-coated protective paper.

More Than a Tape

Angier's Double-Face Film is available in narrow "tape" widths, as well as in wide goods, and shipped in rolls. For these reasons it is sometimes confused with conventional adhesive tapes. Yet it is entirely different from single or double coated tapes with a paper, cloth, or plastic base. Double-Face, with its almost invisible reinforcing tissue, provides as much as 4 mils of adhesive — similar to a solution applied coating — whereas most double coated tapes have an adhesive coating in the range of 1½ mils on each side.

Sizes and Strengths

Angier's film is available in three different adhesive strengths: PT-5501 (soft), PT-5502 (medium) and PT-5503 (firm). It is shipped in 72 linear yard rolls in widths ranging from ⅛" up to 54".

Transfer Film No.	Bond Strength (Peel) lbs./inch width	Dead Load (Shear) 100° F 2½ lbs. wt.	Softening Point		Sustained Dead Load Values in Shear at 75-100° F.		
			Load 50 gms.	Load 225 gms.	*SMOOTH SURFACES bonded with 180° heat and pressure or pressure only	†POROUS SURFACES bonded with pressure only	†POROUS SURFACES bonded with 180° heat and pressure
PT-5501	3.0#	180 secs.	140° F.	110° F.	1 oz.	1 oz.	2 oz.
PT-5502	4.25#	640 secs.	160° F.	120° F.	2 oz.	½ oz.	3 oz.
PT-5503	3.5#	2700 secs.	200° F.	145° F.	12 oz.	½ oz.	5 oz.
ASTM TEST METHOD	D 1000—53 T		D 816—51 T		Values above are all in ounces per square inch		

Write to Angier for prices and for further information regarding Double-Face Pressure-Sensitive Transfer Film and your product requirements.

ANGIER ADHESIVES

*like metal to metal, mylar to steel, polyethylene to polyethylene
†like duck to duck, paper to paper, felt to wood

Values listed in this table are averages and are not intended as specifications.

INTERCHEMICAL CORPORATION
Finishes Division
120 Potter St., Cambridge 42, Mass.
Midwestern Plant: Huntington, Ind.

For more information, turn to Reader Service card, circle No. 497

STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

Tin becomes gold . . . when alloyed with copper to produce a 24-kt. gold brilliance for attractive decorative finishes. The ratio of tin to copper is 12% to 88%. When the tin content is increased to 20%, the alloy takes on a pale yellow hue. Tin-bronze is reported to eliminate the usual alloy plating difficulties. It is as easy to control as single metal deposition.

★

Superior to nickel plate in hardness and abrasion resistance—that is how the product of a new, highly decorative electroplating process is described. The new plating, successfully used for several metals, is a 50-50 tin-copper alloy. It maintains its original color up to its own melting point.

★

Exceptional resistance to salt spray dictated approval by the U.S. Navy's Bureau of Aeronautics of an electrodeposited cadmium-tin alloy . . . 75% cadmium, 25% tin. This rugged alloy protects Navy hydroplane engines from the corrosive action of salt water.

★

Tin is tough. That is why a plating of tin is commonly applied to automotive pistons. It prevents damaging scuffing during engine break-in. The plating serves as a protective lubricant.

Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau

Dept. 24J, 1028 Connecticut Ave., Washington 6, D.C.

For more information, circle No. 449

News OF INDUSTRY

ize in the manufacture of components of solid fuels for rockets and guided missiles.

Hawkridge Bros. Co. has purchased Monsanto Chemical Co.'s **Planishing Plate Div.**

Societies

American Society for Testing Materials has elected the following 1958-59 officers: president — Kenneth B. Woods, Purdue University; vice president—A. Allan Bates, Portland Cement Assn.; and senior vice president—Frank L. LaQue, International Nickel Co. Directors are: Paul A. Archibald, Baldwin-Lima-Hamilton Corp.; William L. Fink, Alcoa Research Laboratories; Harry M. Hancock, Atlantic Refining Co.; Lawrence A. O'Leary, W. P. Fuller & Co.; and Alfred C. Webber, E. I. du Pont de Nemours & Co., Inc.

The following men have been elected to honorary membership: H. J. Ball, Lowell Technological Institute; T. S. Fuller, General Electric Co.; J. L. McCloud, Ford Motor Co.; and J. G. Morrow, Steel Co. of Canada, Ltd.

ASTM also announces the following recipients of 1958 Awards: W. G. Renshaw and R. A. Lula, Alleghany Ludlum Steel Corp.—Sam Tour Award for their paper, "The Corrosion Properties of Chromium-Nickel-Manganese Austenitic Stainless Steel"; John E. Dorn, Thomas A. Trozera, University of California, and Oleg D. Sherby, U. S. Office of Naval Research—Charles B. Dudley Medal for their paper, "The Effects of Creep Stress Histories at High Temperatures on the Creep of Aluminum Alloys"; and A. F. Robertson, Daniel Gross, and Joseph J. Loftus, National Bureau of Standards—Richard L. Templin Award for their paper, "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source."

Society of Plastics Engineers has moved to 65 Prospect St., Stamford, Conn.

Drop Forging Assn. announces the following officers: president—Gordon R. Walker, Walker Forge, Inc.; vice president—Louis M. Fehrenbach, Indianapolis Drop Forging Co., Inc.; and secretary-treasurer—Dwight M. Allgood. Named to the executive committee is Harold F. Wood, Wyman-Gordon Co.

(News of Meetings on p 204)

GRAPHITE AIDS METALLURGY

Standard and custom grades of Graphite Specialties graphite are being employed as molds, dies, crucibles and piping in the production of titanium as well as for chlorinating a wide range of metals. Formulations with individualized properties are available, or "GRAPH-I-TITE" can be furnished.

"GRAPH-I-TITE" is the first impervious graphite. It is immune to thermal shock, non-contaminating, not wetted by molten metal, and is unaffected by practically all corrosives, even at elevated temperatures above 1,000° F.

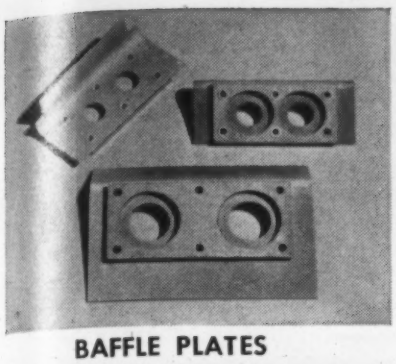
Custom grades of Graphite Specialties graphite are regularly produced with a critical level of purity, almost unbelievable strength, and fine, uniform texture. Other properties of density, porosity, and machining characteristics can be supplied to requirements.

Components and equipment made from Graphite Specialties graphite grades can feature low neutron-capture cross section and high scattering cross section for moderator, reflector, fuel elements, structural parts and piping in nuclear reactors; seals, bearings and other mechanical shapes featuring temperature resistance to 5,000° F. and hardness to 5 Mohs; pipe and cylinders for electric furnace construction; processing equipment for difficult applications such as handling chlorine up to 5,000° F; and rocket nozzle inserts with a very low erosion rate.

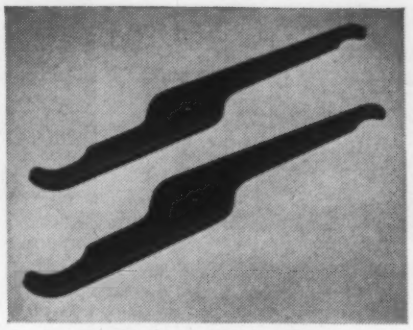
Most types of Graphite Specialties graphite can be furnished in rod, tube, sheet and block form, or can be molded or extruded in special shapes, or can be machined to close tolerance.

Write to GRAPHITE SPECIALTIES CORPORATION, 64th & Pine Avenue, Niagara Falls, New York.

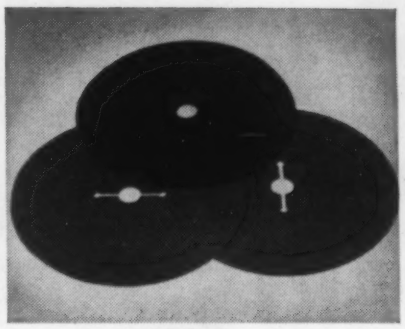
For more information, circle No. 375



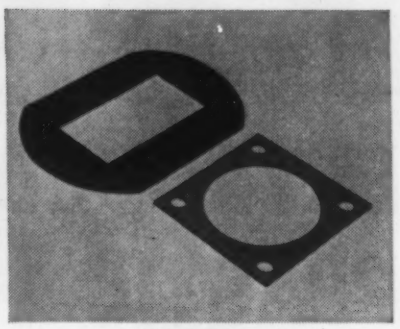
BAFFLE PLATES



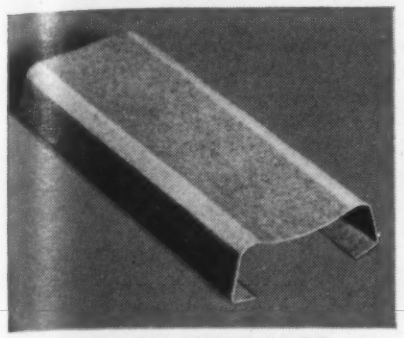
FUSE-PULLER PARTS



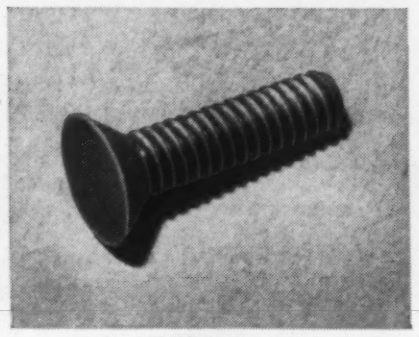
DISCS



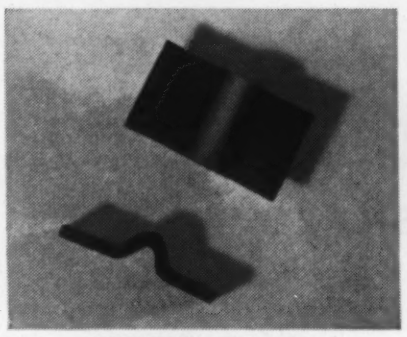
GASKETS



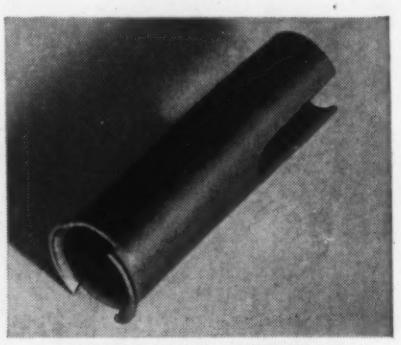
FORMED INSULATOR



SCREW



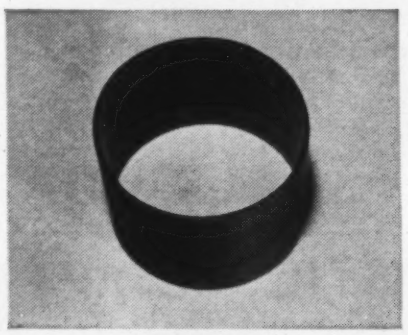
FORMED CLAMPS



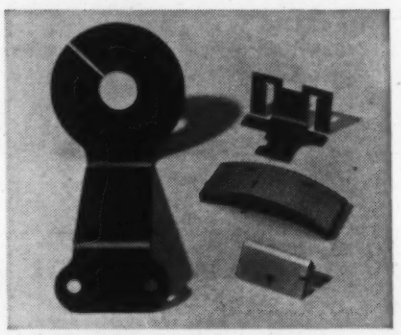
INSULATING BUSHING

SPOOL

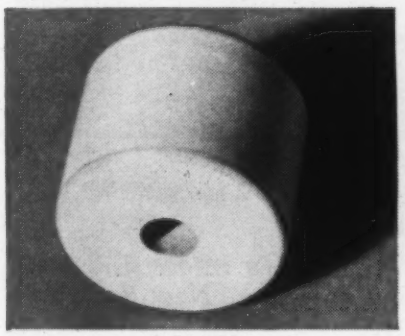
CABLE GRIPE



BUSHING

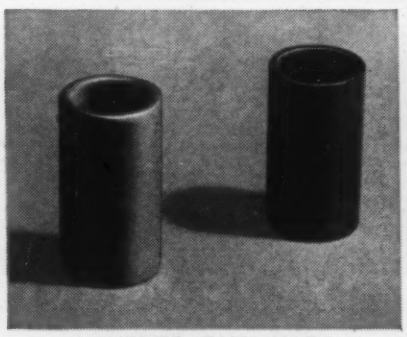


FORMED INSULATORS

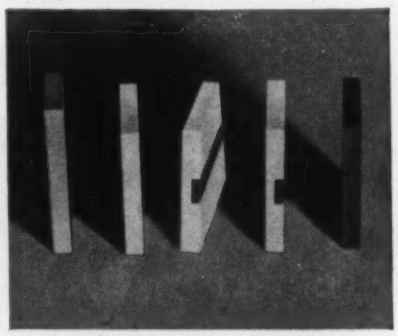


ROLLER

NUMBER TAG



BINDER BUSHINGS



GOLF-CLUB FACINGS

FIBRE – the low-cost insulation of 1001 uses

Look what Diamond Vulcanized Fibre can do for you! And look what *you* or CDF can do with *it!*

If you can keep high-quality fibre clear of its worst enemy—moisture—you have the best economical insulating material you'd ever want for high arc-resistance, non-tracking, and long-time dielectric strength.

UNIQUE PROPERTIES • The high tensile, flexural, and impact strengths, the easy workability (ideal for screw machines), the Rockwell hardness (to R80), the light weight (half that of aluminum), the low cost, and the excellent electrical characteristics (arc-resistance up to 150 sec.) of CDF Fibre make it a highly attractive basic insulation for cost-conscious designers and purchasing men. Put these properties to work in your product.

FABRICATION FACILITIES • CDF has excellent and extensive facilities and know-how for turning out finished Diamond Vulcanized Fibre parts—better and more economically than you can do it yourself. We meet *your* specifications and *your* production schedules, and save you time and money in the bargain.

Send us your print or your problem, and we'll return technical literature. For the phone number of the CDF sales engineer nearest you, see Sweet's, Electronics Buyers' Guide, and other directories.

CDF makes Di-Clad printed-circuit laminates, Diamond Vulcanized Fibre, CDF products of Teflon, flexible insulating tapes, Dilecto laminated plastics, Celoron molded products, Micabond mica products, Spiral Tubing, Vulcoid.

CDF **CONTINENTAL-DIAMOND FIBRE**

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 25, DEL.

For more information, turn to Reader Service card, circle No. 425

For more information, turn to Reader Service card, circle No. 503

ACE for EXTRUDED PLASTIC PARTS fast... at low cost

RODS • TUBES • SHAPES

in all colors... in your choice of

PLEXIGLAS • LUCITE • ETHYLCELLULOSE
POLYETHYLENE • ACETATE • BUTYRATE

in stock... or quickly made to your specifications.

Write, wire, phone for Bulletin E, samples and prices . . . or send specifications, blueprints, for immediate quotation.

ACE PLASTIC COMPANY
91-48 Van Wyck Expwy., Jamaica 35, N. Y. JAmaica 3-5500

Production costs too high?
BOSSERT METAL STAMPINGS
offer many ways to reduce costs!

Whether your product is in the planning stage or in production, you can often reduce costs by using metal stampings for parts or complete assemblies. Complex forms can usually be produced with fewer operations, with holes punched to exact dimensional accuracy, eliminating separate drilling, machining and assembling.

Several parts can be combined in a single stamping, and you can take advantage of the weight-saving features of lighter metals and alloys without sacrificing strength or durability. Your present production costs can be reduced, too, with Bossert's superior quality and dependable service.

Design Engineering Service

Bossert's re-design service can help you develop stampings for parts and assemblies that are now being cast or forged or machined, usually with substantial savings in cost. Send us blue prints or samples for our recommendations.

Write for literature
Find out how our facilities can be helpful to you.

©1958 Rockwell-Standard Corporation

ROCKWELL R STANDARD ®

ROCKWELL-STANDARD CORPORATION
STAMPING DIVISION
1010 OSWEGO STREET UTICA, NEW YORK

For more information, turn to Reader Service card, circle No. 511

News OF INDUSTRY

Meetings

INSTRUMENT SOCIETY OF AMERICA, 13th annual instrument automation conference and exhibit. Philadelphia. Sept 15-19

STEEL FOUNDERS SOCIETY OF AMERICA, 56th fall meeting. Hot Springs, Va. Sept 22-23.

IRON AND STEEL EXPOSITION, Assn. of Iron and Steel Engineers. Cleveland. Sept 23-26.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept 25-27.

ELECTROCHEMICAL SOCIETY, fall meeting. Ottawa, Ont. Sept 28-Oct 2.

PRESSED METAL INSTITUTE, annual meeting. Sea Island, Ga. Sept 28-Oct 2.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual meeting and western tool show. Los Angeles. Sept 29-Oct 3.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aeronautic meeting, aereonautic production forum and aircraft engineering display. Los Angeles. Sept 29-Oct 3.

GRAY IRON FOUNDERS SOCIETY INC., annual meeting. Washington, D. C. Oct 8-10.

DESIGN MATERIALS SHOW, Industrial Designers Institute. New York City. Oct 8-10.

METAL POWDER INDUSTRIES FEDERATION, fall meeting. French Lick, Ind. Oct 8-11.

INSTITUTE OF METALS DIV., American Institute of Mining, Metallurgical & Petroleum Engineers, Inc., fall meeting. Cleveland. Oct 27-30.

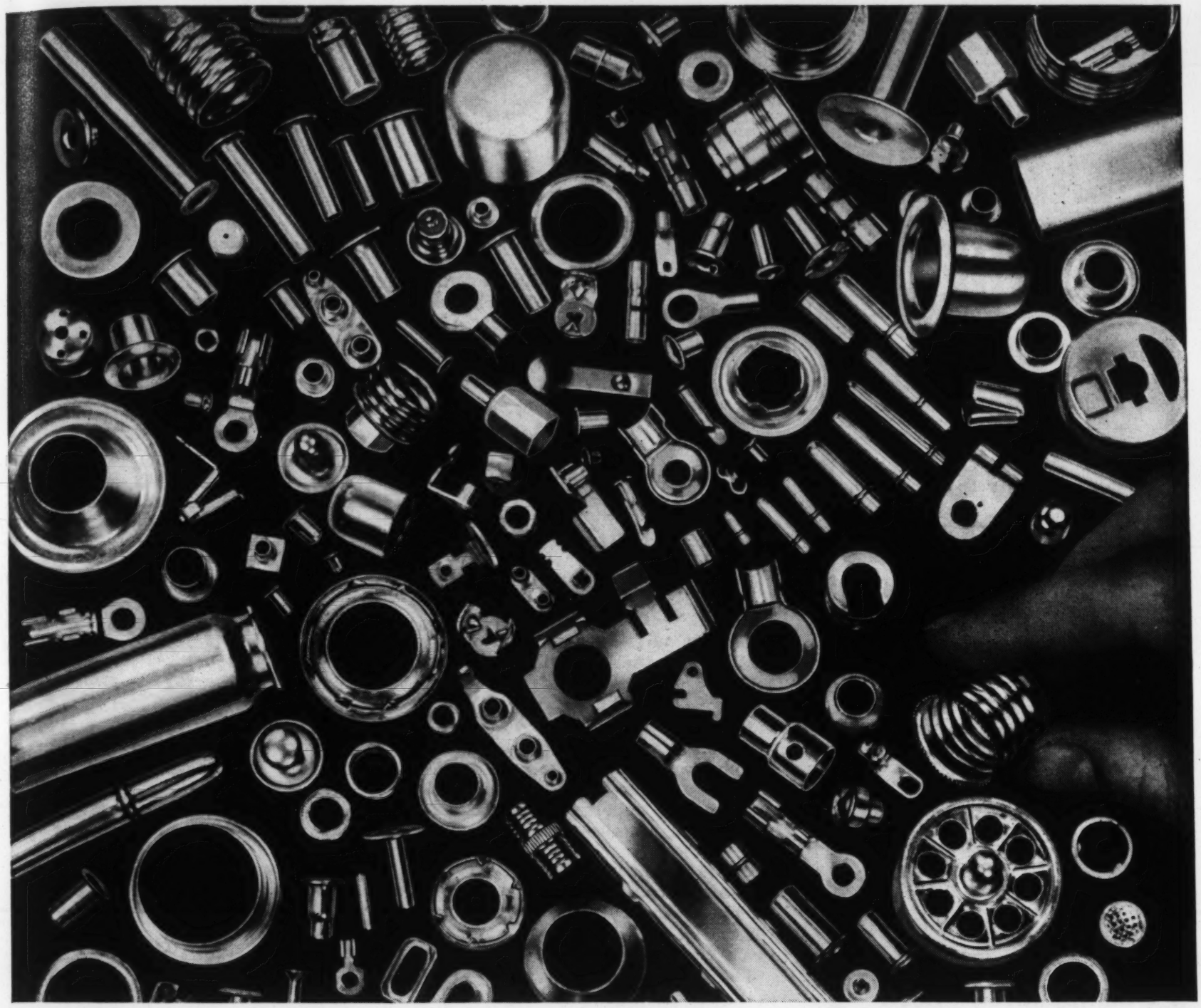
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Pittsburgh. Oct 27-31.

1958 ANNUAL NATIONAL METAL EXPOSITION AND CONGRESS, American Society for Metals. Cleveland. Oct 27-31.

METAL TREATING INSTITUTE, annual meeting. Cleveland. Oct 29-31.

STEEL FOUNDERS' SOCIETY OF AMERICA, 13th annual technical and operating conference. Cleveland. Nov 10-12.

4TH CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, American Institute of Electrical Engineers, American Physical Society, Institute of Radio Engineers, Metallurgical Society of AIME, and Office of Naval Research. Philadelphia. Nov 17-20.



All of these parts were designed to serve a specific function—at a lower cost. Some are made by customer-owned tools.

Pick a part! any part . . . any metal

Then ask us for an eye-opening quotation

These are only a few of the thousands of multiple-plunger and progressive-tool press products we supply to every branch of industry—from simple eyelets to precision electronic components.

We offer a complete design-engineering service based on long experience and specialized production equipment, and are often able to suggest ways and means of using our stock tools to further cut costs.

Simply send us a sample, drawing or description of the parts you need, plus the quantity. The metal can be copper, brass, bronze, nickel silver, nickel, iron, steel, stainless steel or aluminum . . . and in any applied or plated finish you choose.

Send your inquiry to: The American Brass Company, Fabricated Metal Goods Division, Waterbury 20-A, Conn.

5852

STOCK PRODUCTS: Write for catalog BG-1, showing a selection of more than 1,000 eyelets and seamless base pins of common sizes and styles, many of which are kept in stock for immediate shipment.

ANACONDA®

Multiple-Plunger Press Products

For more information, turn to Reader Service card, circle No. 489

PLAST-IRON POWDERS

NEW

Grade B-280

Reduced • 80 Mesh

Improved Sponge Iron Powder

•

Complete Interchangeability For Present Dies

•

Competitively Designed

•

Competitively Priced

PM 6d

Send for Technical Data and Working Sample

PM PLASTIC METALS

PLASTIC METALS

Division

National-U.S. Radiator Corporation

4458 BRIDGE STREET

JOHNSTOWN, PA.

For more information, circle No. 369

TECHNICAL LITERATURE

(cont'd from p 43)

Books

Insulation Engineering Fundamentals. *Graham Lee Moses. Lake Publishing Corp., 718 Western Ave., Lake Forest, Ill. 1958. Cloth, 8¼ by 11¼ in., 118 pp. Price $2.75 (paperbound), $6 (clothbound)*

According to the author, it is the objective of this book to present the basic concepts that form the foundation of insulation engineering, together with discussions of the present status of insulation engineering in several fields. The book includes examples of how insulation is used, its importance and its achievements. The weaknesses of electrical and electronic insulation and the problems that may arise in their use are discussed in the light of present-day technology on a variety of equipment.

Graham Lee Moses is widely recognized as a leading authority on electrical insulation and is the author of more than 100 technical articles and papers as well as another book on electrical insulation.

Radioisotopes: A New Tool for Industry. *Sidney Jefferson. Philosophical Library Inc., New York, 1958. Cloth, 5 by 7½ in., 116 pp. Price $4.75*

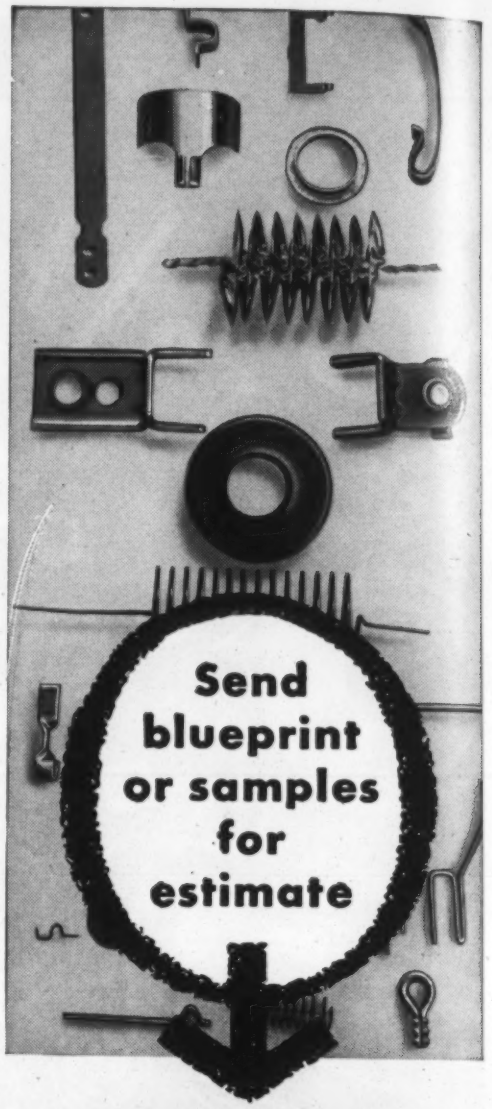
The first part of this book gives examples of the many ways radioactive materials can be used for industrial applications. One example is the detection of leaks in tanks and pipes; another is checking the thoroughness of mixing by adding radioactive materials to the compounds being mixed.

The second part of the book explains the elementary fundamentals of radioactivity, covering atomic structure, atomic energy, atomic piles, transmission and detection of radiations, and health precautions essential to individuals working with radioactive materials.

A Guide to Plastics: 2nd Edition. *C. A. Redfarn. Philosophical Library, Inc., New York, 1958. Cloth, 5½ by 8½ in., 150 pp. Price $7.50*

The author of this book gives a picture of the whole field of plastics and explains what "plastics" are and how they are made. He describes the basic and intermediate raw materials used in the manufacture of plastics and the various molding processes by which these materials are fabricated into finished goods.

Featured in the book are 17 color charts which show all the



WIRE FORMS and METAL STAMPINGS

We'll prove that our high speed production means lower unit costs for you!

You'll save two ways — (1) the initial low unit cost made possible by high speed machines; (2) precision and quality control guarantees accurate parts and performance.

STRAIGHTENING AND CUTTING
Perfect straight lengths to 12 feet.
.0015 to .125 diameter.

WIRE FORMS
.0015 to .125 diameter.

SMALL METAL STAMPINGS
.0025 to .035 thickness.
.062 to 3 inches wide.

Specializing in production of parts for electronic, cathode ray tubes and transistors.

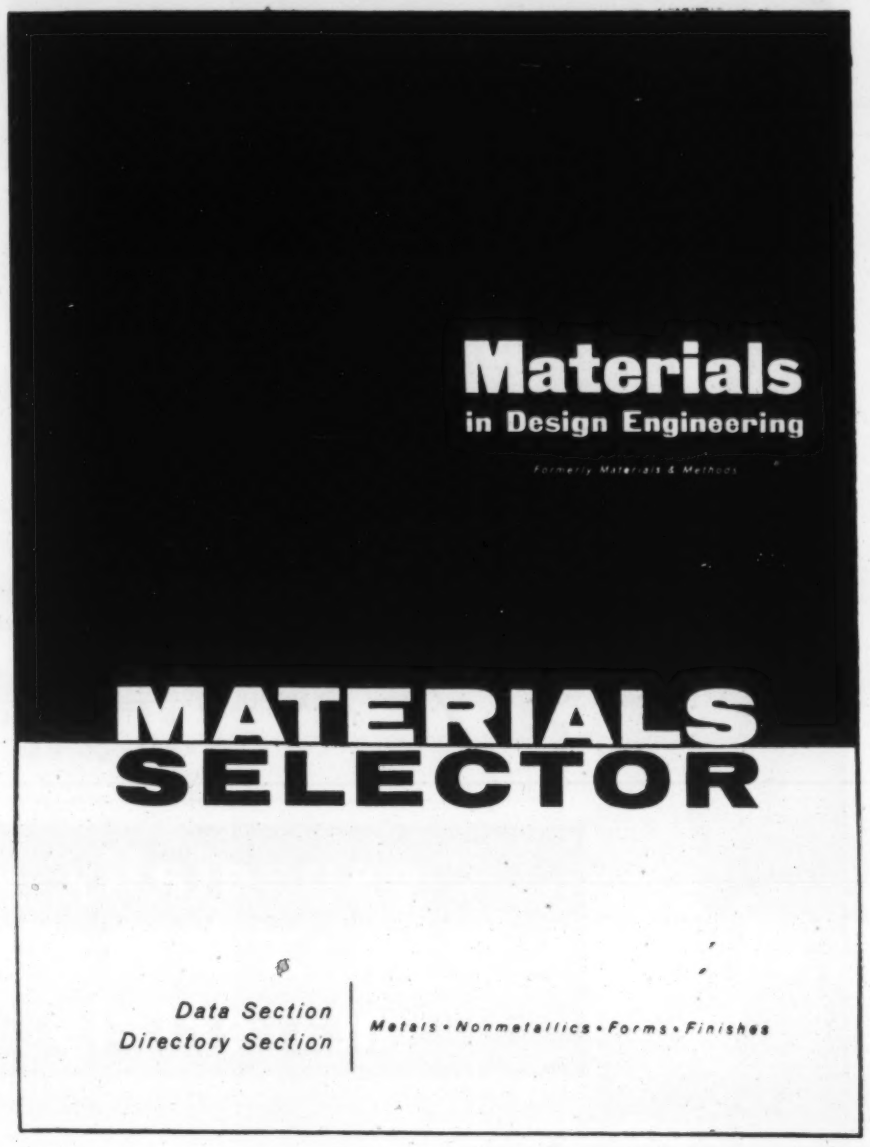
Write for illustrated folder.

ART WIRE AND STAMPING COMPANY

13 BOYDEN PLACE, NEWARK 2, N. J.

For more information, circle No. 370

Keep this on your desk...



MATERIALS SELECTOR ISSUE

If you're a subscriber to MATERIALS IN DESIGN ENGINEERING you have a copy of the 1957-1958 MATERIALS SELECTOR. If you keep the SELECTOR within easy reach and form the habit of using it regularly, you'll find it a time saver. Here are some of the reasons why. . . .

WHAT IT IS: All editorial pages of the MATERIALS SELECTOR are in data sheet form. These provide materials-specifying engineers, designers and other technical men with the most complete and best organized annual reference data available. It offers you two major editorial sections:

Data Section
- Comparisons of Materials
- Properties of Materials
  - Irons and Steels
  - Nonferrous Metals
  - Plastics and Rubber
  - Nonmetallics *(except Plastics and Rubber)*
- Finishes and Coatings
- Forms and Shapes of Materials

Directory Section
- Suppliers of Materials *(classified by Materials, Forms, and Finishes)*
- Addresses of Suppliers

WHY M/DE PUBLISHED IT: You and your fellow readers continually ask us for information of all sorts about materials selection. In fact, requests for further information resulting from MATERIALS IN DESIGN ENGINEERING's editorial and advertising pages average better than 225,000 per year! Until now, no one has ever attempted to consolidate reference data in a single annual issue and thus make it easier to determine the answers to the problems that confront you when you select and specify engineering materials.

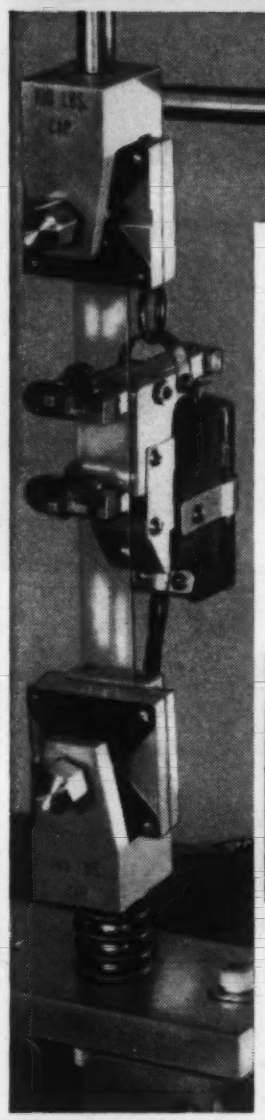
WE'RE EXCITED because our readers have been given just what they want in the MATERIALS SELECTOR. Get into the habit of using it. We know you'll find it the most complete, the most useful, year-round reference issue published.

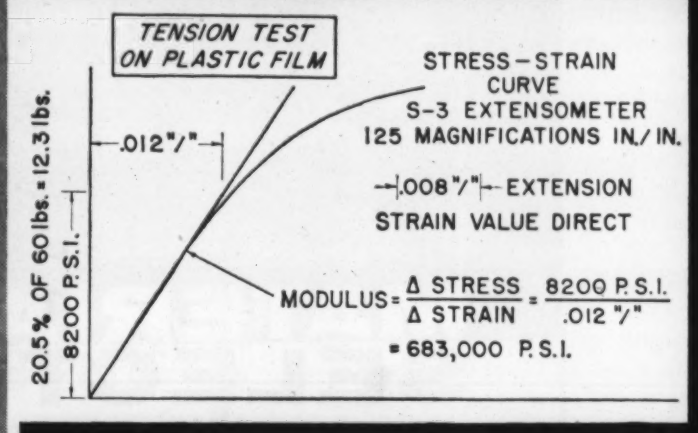
The Editors

Materials in Design Engineering

The MATERIALS SELECTOR *is not sold separately—available only by subscription to* MATERIALS IN DESIGN ENGINEERING.

Are Your Test Results Accurate?



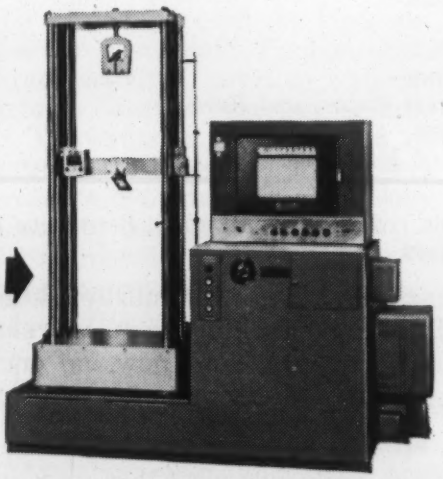


. . . especially with LOW TENSILE materials

The Olsen XY Electromatic is the ONE testing machine that produces *true* stress-strain curves with such low tensile materials as non-rigid plastics, films, metallic foils, fibres, rubber, fine wire, etc. Using exclusive Olsen counterbalanced instrumentation, an extensometer is attached directly to the specimen without impairing it or imposing any external load.

Strain (not time or crosshead motion) is recorded in terms of actual deformation in inches per inch between gauge points on the specimen itself. Thus, the inaccuracies of "calculated" strain based on crosshead motion are eliminated. Fundamental engineering data can be obtained from Olsen XY Electromatic curves with full assurance of accuracy and reproducibility at temperatures from –85°F. to 2000°F.

"ARE YOUR TEST RESULTS ACCURATE?" . . . an informative brochure on low capacity testing is awaiting you. Write for your copy today.



Positive, infinitely variable testing speeds, unlimited stroke, plus all the flexibility of a built-in XY Recorder . . . the XY Electromatic is a truly Universal Testing Machine. All scale ranges are calibrated, sealed and ready for instant use . . . and the range can be changed during test with a flip of the Selectrange switch. In addition, Olsen offers a complete line of instrumentation and testing tools.

TINIUS OLSEN
TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

Trademark
Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 422

TECHNICAL LITERATURE

stages of manufacture from raw materials to finished goods in each of the main categories of plastics.

Reports

Thermal properties of metals THERMAL PROPERTIES OF THIRTEEN METALS. *C. F. Lucks and H. W. Deem, Battelle Memorial Institute. 1958. 30 pp. Available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Price $1.25 (ASTM Special Technical Publication No. 227)*

Thermal conductivity, linear thermal expansion, specific heat, density and thermal diffusivity values are reported for the following metals: 2024-T4 and 7075-T6 aluminum from –250 to 800 F; chromium from 75 to 3000 F; copper from 75 to 1900 F; magnesium from –250 to 600 F; and molybdenum from 75 to 3000 F.

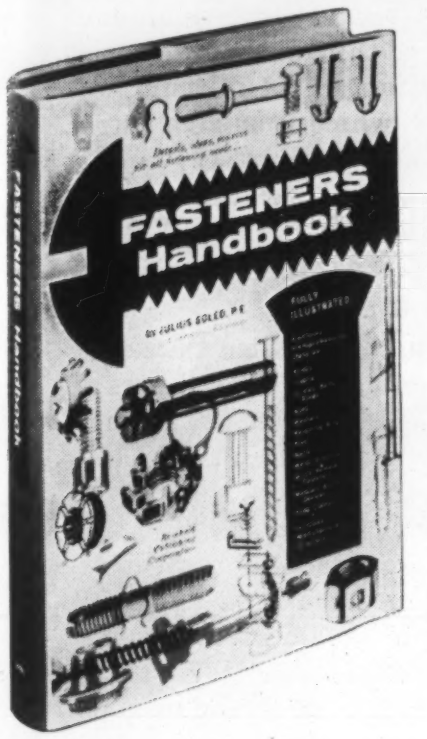
Coatings for magnesium HIGH TEMPERATURE PROTECTIVE COATINGS FOR MAGNESIUM. *C. R. Fitzgibbon, E. H. Miller and M. A. Glaser, Midland Industrial Finishes Co. Apr '57. 112 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 131073)*

Three air drying coating systems were developed for effective protection of magnesium aircraft structural materials against both high temperature and high humidity. One system, based on an epoxy-polyamide vehicle, is the best of the three but it loses its color retention at high temperatures. The other two coatings are based on 1) a styrenated acrylonitrile-modified alkyd-silicone copolymer resin, and 2) a mixture of an epoxy ester and a silicone resin.

Nickel NICKEL AND ITS ALLOYS. *J. G. Thompson, National Bureau of Standards. Feb '58. 87 pp. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 60¢ (NBS 592)*

Among the topics covered in this report are: optical, thermal, electrical, magnetic and mechanical properties of high purity and commercial forms of nickel, as well as properties and industrial applications of its important ferrous and nonferrous alloys. About 800 supplementary references are listed as sources of further information.

Details, ideas, sources
for all engineering, mechanical and manufacturing needs



FASTENERS Handbook

by JULIUS SOLED, P.E.
Consulting Engineer

1957, 448 pages, $12.50

Over 900 Illustrations!

FASTENERS HANDBOOK provides ready, up-to-date answers to fastener problems in all fields. Its pertinent data, illustrations, and full page descriptions supply you with detailed information on currently available fasteners. Here is a *handbook* in every sense of the word. You can *select* the fastener you want because this comprehensive book includes standard and proprietary fasteners from all manufacturers. These include the many specialized fasteners developed since the Second World War; specific fasteners that increase structural safety and reliability; and the whole range of sizes and type of materials available.

This is the *only* fastener reference which relates the actual uses of fasteners in one industry to those of another. The result is concrete examples of money-saving applications for all designers and manufacturers. The book also points out the plus values of many less known but equally valuable fasteners.

The coverage is unusually complete, accurate, and up-to-date. Every description of a proprietary fastener has been verified by its manufacturer. All major manufacturers and most smaller ones have supplied material. The industry associations such as the Fasteners Institute and the Screw Bureaus have likewise contributed.

Fastener development has far exceeded the published information on fasteners. This handbook meets the tremendous need for a reliable, current, and authoritative reference to fasteners and fastener resources.

Due to its complete coverage, Fasteners Handbook can be profitably used by design engineers, mechanical engineers, patent attorneys, sales personnel, fastener distributors and jobbers—in fact, anyone who needs solid information on fasteners available for mechanical assembly.

Abounds in Profitable Features

FASTENERS HANDBOOK

Brings to your attention the many cost-saving features of available, less-known fasteners.

Presents complete fastener lines in particular fields and applications. Enables you to look at what's available before closing up.

Makes possible the immediate location of every fastener described with name and address of supply source.

Relates actual uses of fasteners in one industry to those of another, resulting in concrete examples of money-saving applications.

Everything in Fasteners

RIVETS

INSERTS

SCREWS, BOLTS, STUDS

Standard Screws and Bolts; Miscellaneous Standard Bolts; Standard Studs; Load Indicating Screws and Bolts; Locking Screws and Bolts; Recessed Head Screws and Bolts; Sealing Screws and Bolts; Structural Bolts; Studs; Tapping Screws; Wood Screws and Bolts; Miscellaneous Screws and Bolts.

NUTS

Standard Nuts; Free-Spinning Locknuts; Prevailing-Torque Locknuts; Nonlocking Nuts.

WASHERS

RETAINING RINGS

PINS

NAILS

METAL STITCHING

QUICK RELEASE FASTENERS

MASONRY ANCHORING DEVICES

HOSE CLAMPS

MANUFACTURERS DIRECTORY

Examine Fasteners Handbook Free!
—Send No Money!

MAIL THIS COUPON NOW

REINHOLD PUBLISHING CORPORATION, Dept. M-294
430 Park Ave., New York 22, N. Y.

Please send me the FASTENERS HANDBOOK to read and examine free. In 10 days I will return the book and owe nothing or I will remit $12.50, plus postage.

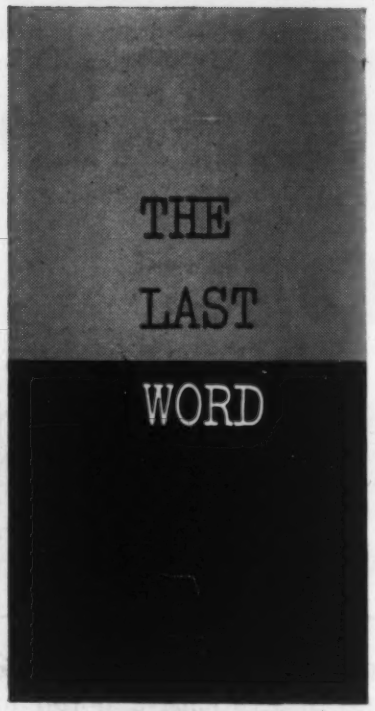
NAME .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

☐ **SAVE MONEY!** Check here if you ENCLOSE payment, in which case we pay all shipping charges. Same return privilege. Refund guaranteed. Please add 3% sales tax on N.Y.C. orders.

For more information, turn to Reader Service card, circle No. 464



by John B. Campbell, *Managing Editor*

As we go to press on this issue, editor Hank Clauser has not yet returned from a long six weeks of business and pleasure on the West Coast. Faithful followers of this column can be sure, however, that he will be back in this spot again next issue.

Fifteen Centuries of Composite Metals

A new exhibition of oriental arms and armor at the Metropolitan Museum of Art here in New York City is of more than passing interest to a metallurgist. For here you can see some superb examples of craftsmanship dating from as far back as the fourth century, many of them representing a high degree of metallurgical skill in the days when metallurgy was both a decorative and a utilitarian art, but hardly a science.

Of particular interest are the many striking examples of the use of composite metals. Laminating was often necessary because of the limited size of the refined metal "cakes" and bars available at the time, and both inlaying and laminating of dissimilar metals were widely used to produce decorative effects. For details on some of the techniques used we are indebted to a recent issue of the Museum's *Bulletin.*

Inlaying precious metals in steel, known as "damascening," has been done since ancient times. A striking example of this technique in the Museum's collection is a 17th century Persian cuirass in which gold is used to inscribe a flowering vine and various Arabic characters. The design was made by roughing up the steel plate in criss-cross fashion, laying down gold wire on this roughened surface, and hammering the roughed steel in such a way that the points bent down to clinch the gold in position.

Inlaying was not the only method of attaching gold to steel. Some of the Japanese armor illustrates what is probably the earliest technique: iron was covered with a thin sheet of copper, which was cleaned thoroughly; hot mercury was applied to the copper with which it amalgamated; gold leaf was laid upon this surface; and a stronger heat was applied, volatilizing the mercury and leaving the gold perfectly adherent.

Laminated Barrels and Blades

The collection also includes so-called Damascus gun barrels—made by laminating several bars of iron and steel together and welding, then twisting spirally and welding again. The process resulted in intricate patterns, and the barrels were often inlaid with gold as well.

The famous "Damascus blade" of medieval times is well represented. Damascus blades, it turns out, were not made at Damascus but at Kona Samundrum in Haiderabad. Whatever their nationality, these blades are a good example of the early use of composite metals. Since the steelmaking process of the time resulted only in small steel cakes, a blade had to be made up of many bars welded together in layers. The blade was forged at low temperatures so as not to lose the cementite which is responsible for the characteristic swirl pattern of the blades.

The Malay kris, on the other hand, started with a steel base which formed the edge; to it was welded on both sides a laminated scroll of alternately thick and thin bars of iron and meteoric (nickel-containing) iron. A thin layer of steel was welded on top of the iron. When the blade was forged, the loose welds in the laminated ("damask") iron permitted steel to be driven between the laminae, producing a striated effect—an effect which became multicolored during the long reforging and reheating process.

In Japan, swords were venerated and as a result were produced with extreme care. Some of the best swords were made by welding together a strip of iron and a strip of steel, folding this compound strip on itself, welding it together, drawing it out to the original length, and repeating the process to produce a billet containing many thousands of alternate layers of the two metals. This billet was forged into a sword.

Plastic Hits a New High—and Returns

Being human beings as well as editors we try not get out on a limb more often than necessary, and if we get sawed off we try not to tell anyone about it. But when it turns out we picked the right limb, we like to let people know. So, please note that our speculation in this column in the June issue that the Jupiter rocket's re-entry nose cone was made of a reinforced plastic was proved correct in July.